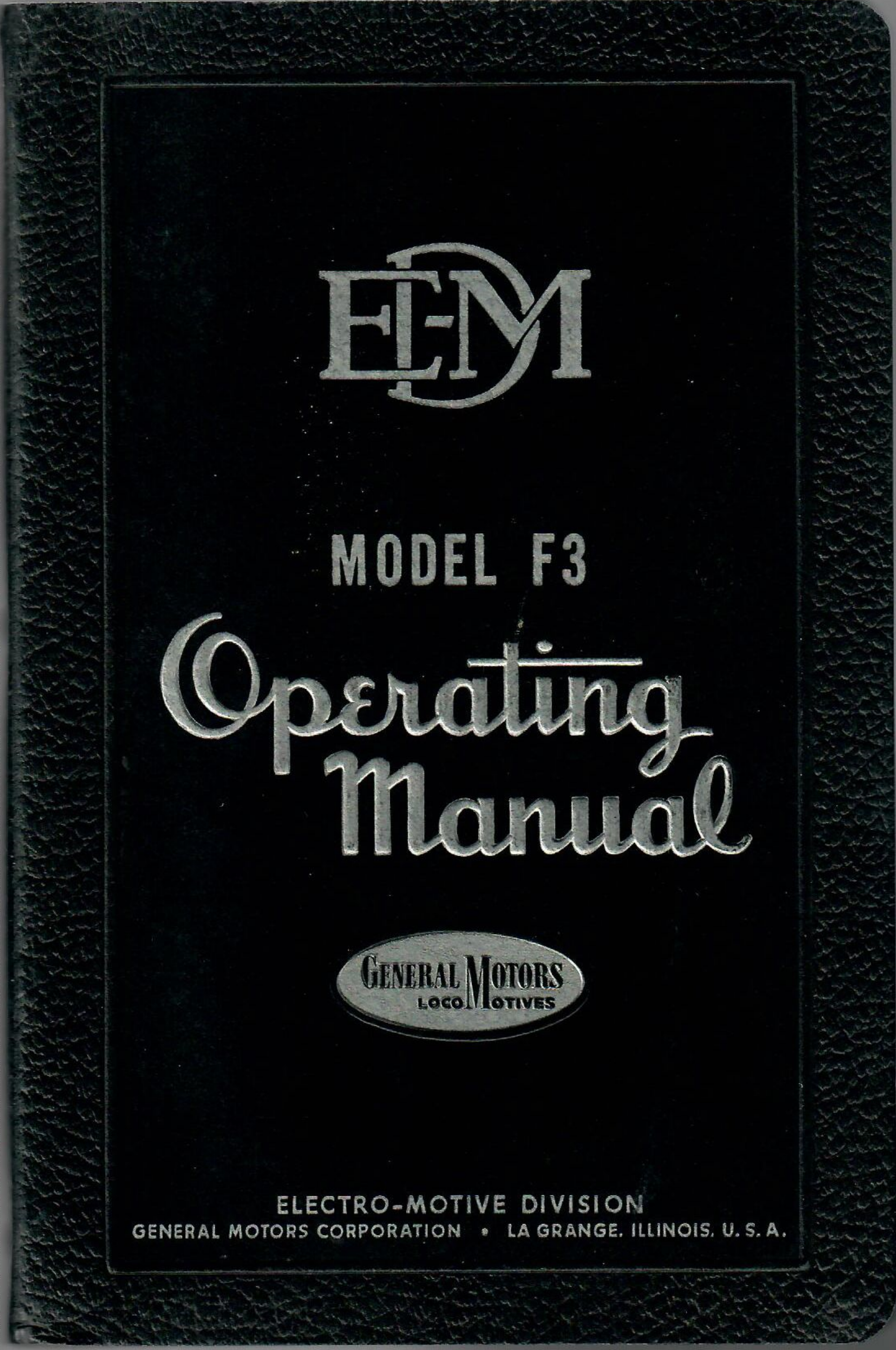
EMD MODEL F3

MODEL F3

Operating Manual

GENERAL MOTORS
LOCOMOTIVES

ELECTRO-MOTIVE DIVISION
GENERAL MOTORS CORPORATION • LA GRANGE, ILLINOIS, U. S. A.



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ERIE
ERIE DIESEL
TRAINING CAR #10

DIESEL LOCOMOTIVE OPERATING MANUAL

NO. 2308B

FOR

MODEL F3

5th Edition
November, 1948

This manual covers operation of the F3 locomotives. Coverage of the Dynamic Brake and Automatic Transition are included. The manual is written to be complete with or without this coverage so that on locomotives not equipped with Dynamic Brake or Automatic Transition, reference to these subjects may be eliminated without detracting from coverage of the locomotive.

Price $3.50

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ELECTRO-MOTIVE DIVISION
General Motors Corporation
LA GRANGE, ILLINOIS, U. S. A.

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INTRODUCTION

This manual has been produced for use with model F3 locomotives. It covers basic (standard) equipment as well as the most commonly used "extras."

The typical wiring diagram in the manual includes Dynamic Braking and Automatic Transition. The automatic transition equipment is clearly outlined so that it may be included or deleted from the study of the diagram as desired.

The first two sections of this manual are devoted exclusively to a Description of the locomotive and its operation over the road. Details of construction and detailed descriptions of function are purposely omitted in order to maintain simplicity. This is to permit interested personnel to quickly grasp the fundamentals of operation. As soon as the fundamentals are understood, reference should be made to the remaining sections of the manual which describe in detail the function and operation of the various parts of the locomotive.

The table on the first page in the manual is a ready reference to the various sections. The principle articles (paragraphs) of each section are numbered consecutively for ready reference as is each page of the section. Articles and pages are numbered in the 100 series type of numbering, a page in the 300's in section three as is any article numbered in the 300's.

The appendix contains charts showing features of the locomotives which are of interest to operating personnel. A subject index is included in the manual.

ELECTRO-MOTIVE DIVISION

F3 DIESEL LOCOMOTIVES

GENERAL DATA

Weight (fully loaded) "A" Unit (approx.)	230,000 lbs.
"B" Unit (approx.)	230,000 lbs.
Fuel Oil Capacity (per unit)	1,200 gal.
Lube Oil Capacity (per engine)	200 gal.
Cooling Water Capacity "A" Unit—"G" Valve Level	230 gal.
"B" Unit—"G" Valve Level	215 gal.
Steam Generator Water Tank Capacities (if used):	
Vertical Tank—"A" Unit	500 gal.
"B" Unit	1,200 gal.
Hatch Tank—"A" Unit	600 gal.
"B" Unit	600 gal.
Tank Under 1600# Steam Generator	200 gal.
Gear Ratios and Maximum Permissible Speeds:	
65/12	50 MPH
62/15	65 MPH
61/16	71 MPH
59/18	83 MPH
58/19	89 MPH
57/20	95 MPH
56/21	102 MPH
Sand Capacity (per unit)	16 cubic feet
Number of Drivers (per unit)	4 pair
Wheel Diameter	40"
Weight on Drivers	100%
Truck Centers	30' 0"
Truck Rigid Wheelbase	9' 0'
Minimum Curve Radius	274'
Center of Gravity above Rail (approx.)	63"
Length: Between Coupler Pulling Faces—"A" Unit	50' 8"
"B" Unit	50' 0"
Height: Over Horns	14' 11¼"
Width: Outside Grabirons	10' 8"

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SECTION 1

GENERAL DESCRIPTION

100. The F3 locomotive consists of one or more units rated at 1500 HP each. The units which are equipped with an operating cab are designated "A" units, those without cabs as "B" units. Different combinations of units are used, depending on the horsepower and operating requirements. The 1500 HP locomotives are single "A" units, the 3000 HP either "AA" or "AB" arrangement. The 4500 HP locomotives are "ABA" or "ABB" consist while the 6000 HP are "ABBA" or "ABBB" arrangement.

The locomotive units are functionally independent. "B" units equipped with Hostler controls can be maneuvered independently as can all "A" units. Air hoses and control wires connect the units to provide multiple unit operation from one cab.

101. Diesel engines. Each unit has a 16 cylinder Diesel engine which drives the main generator and auxiliaries described later.

The engines are "V" type with a 45° angle between banks and have a compression ratio of 16 to 1. Solid unit injection is employed with an injector centrally located in each cylinder head. The engines have a speed range of 275 to 800 RPM, which is controlled by an electro-hydraulic governor control operated from the engineer's throttle. In this way, all engines in locomotives of two or more units are controlled simultaneously.

The engines are two stroke cycle. At the lower end of each downward stroke, the piston uncovers a row of ports in the cylinder liner. Scavenging air, supplied (at 3 to 5 pounds) by two blowers mounted on the engine, enters the ports, expels the exhaust gases through exhaust valves in the cylinder head and fills the cylinder with a fresh charge of air. The air is compressed as the piston moves upward, which causes the air to increase greatly in temperature. As the piston nears top dead center, fuel is injected into the space above the piston. The fuel ignites due to the high temperature of the compressed air (900°-1000° F.) and burns to produce power on the downward stroke of the piston.

102. Main generator and alternator. The main generator and alternator assembly are directly connected to the Diesel engine through a flexible coupling. Two electrically separate sections are mounted on the same shaft and designated as model D12-D14. The D12 portion produces direct current at a nominal voltage of 600 volts for operation of the traction motors. The D14 section, built into the engine end of the frame is a 3-phase, 100 KW, alternating current generator which furnishes current to drive the engine water cooling fans, and the traction motor blowers. For more information on main generator see Art. 603, on alternator, see Art. 638.

103. Traction motors. Four model D-17-B traction motors are used in each unit. Each motor is supported by suspension bearings on the wheel axle and by spring mountings on the transom of the truck frame, to provide flexibility. A pinion on each traction motor armature shaft meshes with a gear mounted on the axle of the pair of wheels which it drives. The gear ratio between the traction motor and the wheels is expressed as a double number such as "62/15." In this case, the axle gear has 62 teeth, and the pinion has 15 teeth.

The traction motors are connected either in series-parallel or in parallel, depending on the conditions of operation of the locomotive. In each of these arrangements, electrical shunts may be connected across the fields of the traction motors to maintain high torque as the locomotive speed increases. During acceleration of the train, the successive steps are:

No. 1 Series-parallel.

No. 2 Series-parallel shunt.

No. 3 Parallel.

No. 4 Parallel shunt.

During deceleration due to grade conditions, the steps take place in reverse order. (See Art. 620).

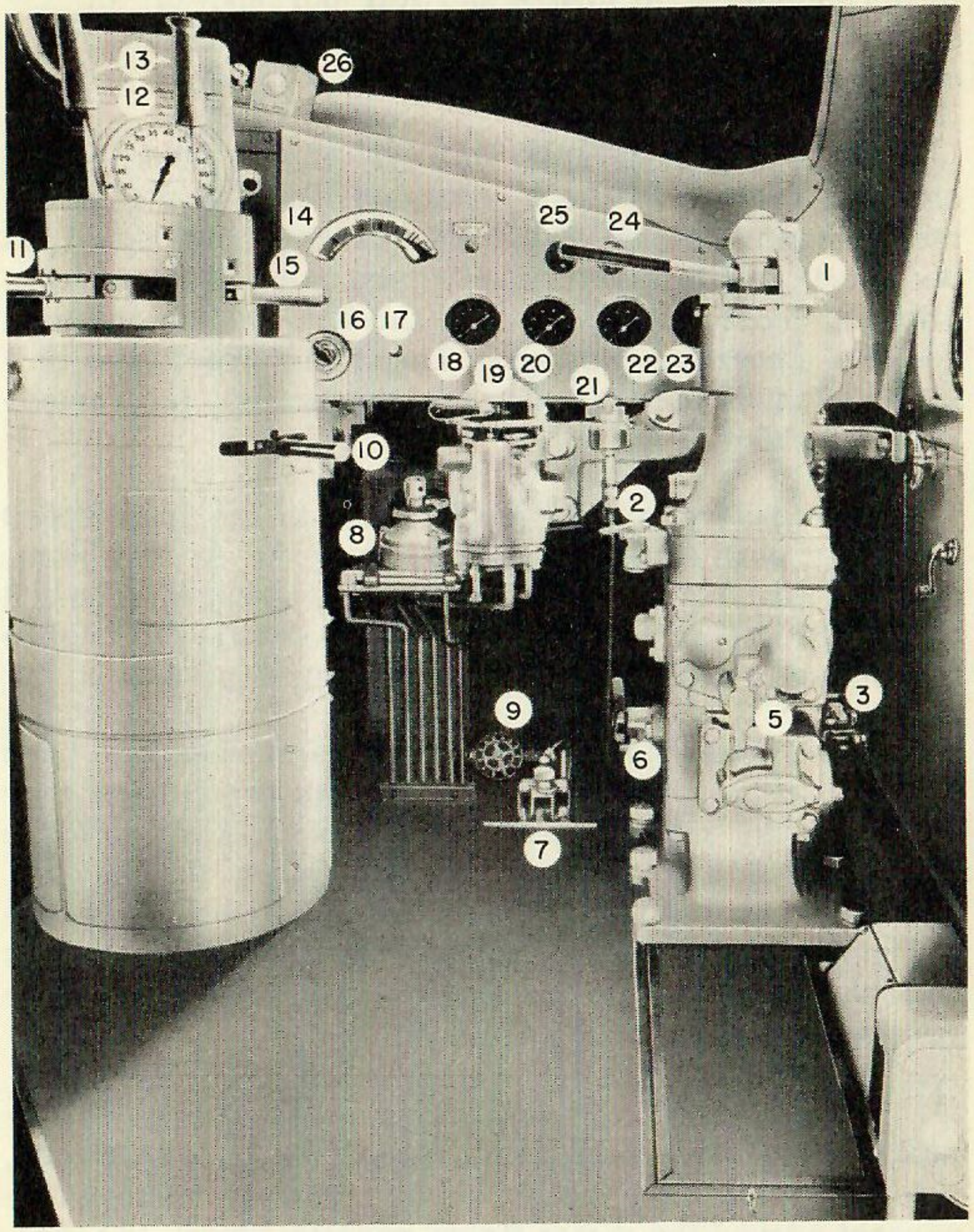
104. The changing of traction motor circuits is called "transition." This is accomplished by movement of the manual transition lever in the engineer's control stand or automatically on locomotives equipped with "automatic transition." Automatic transition provides for automatic changing of traction motor circuits through the forward and backward transition ranges without manual shifting. This is done according to the voltage and current output of the main generator. (See Arts. 156 and 621.)

When the Diesel engine is running with the throttle in the 8th notch, a fixed amount of horsepower is developed by the engine. This engine drives the electric generator that supplies electric current to the traction motors. The motors are connected in series-parallel, Fig. 6-1, for starting a train and for heavy pulling.

As the speed of the train increases the motor armatures turn faster, increasing their back pressure (resistance) forcing the generator voltage to rise. If the generator voltage was unlimited, we could leave the motors in series-parallel and build the voltage up higher and higher to force the necessary amperes (current) through the motors, but, as the generator

LEGEND OF ENGINEER'S CONTROLS

1. Automatic Brake Valve
2. Full Release Selector Cock
3. First Service Position Cock
4. Pneumatic Control Switch (PC) - Manual Operation
5. Safety Control Cock
6. Brake Valve Cutout Cock
7. Safety Control Foot Pedal
8. Rotair Valve
9. Cab Heater Steam Valve
10. Reverse Lever
11. Transition Lever
12. Speed Recorder
13. Horn Cords
14. Load and Transition Indicating Meter
15. Throttle Lever
16. Heater Switch
17. Windshield Wiper Valve
18. Equalizing Reservoir and Main Reservoir Air Gauge
19. Independent Brake Valve
20. Brake Pipe and Brake Cylinder Air Gauge
21. Bell Valve
22. Application Pipe and Suppression Pipe Air Gauge (if used)
23. Engineer's Watch Receptacle
24. Wheel Slip Indicator Light
25. Dynamic Brake Warning Light
26. PCS Open Light



Engineer's Controls
Fig. 1-1

has a limited voltage capacity, it becomes necessary to do something to utilize the full horsepower of the engine, as the engine horsepower output will now begin to fall off, and the train would go no faster.

With the generator voltage at its peak, motor shunting contactors close, shunting some of the generator current around the fields of the motors. This decreases the back-pressure (resistance) of the motors, allowing more current to flow through the motors with reduced generator voltage. The train speed can now increase and the motors are connected in series-parallel-shunt, Fig. 6-2.

The generator voltage will rise as the train speed increases until it again reaches its peak. At this point, little would be gained by shunting more current around the motor fields, so it becomes necessary to change the motor connections to full parallel, Fig. 6-3.

The motor back pressure (resistance) has been reduced so they require about one-half the voltage they did while the motors were in series-parallel to force the required amount of current through the motors. The generator voltage will build up again (with increaseing motor speed) forcing more current into the motors until the train reaches its rated speed, or the generator voltage has again reached its limit.

If the generator voltage has again reached its peak before the rated train speed has been attained, a further step may be taken by shunting some of the current around the motor fields, parallel shunt, Fig. 6-4.

The motor back pressure (resistance) is again reduced, allowing reduced generator voltage to force the necessary amount of amperes (current) through the motors to bring the train up to its rated speed.

When a moving train reaches an ascending grade, it will naturally take more power to climb the grade at the same speed. The engine horsepower is limited and the electrical output of the generator is limited, so no more horsepower is available. As the train slows down on the grade, the motor armatures turn slower and their back pressure (resistance) decreases. With this decrease in resistance, more amperes (current) flow through the motors. If the motors were left in parallel-shunt or parallel, they would draw more amperes than the rated output of the generator, causing the generator to heat. To protect the generator from damage by overheating, the motor connections are changed back to a series parallel hook-up. This will increase the back pressure (resistance) of the motors, forcing the generator voltage up and reduces the generator ampere (current) output to a safe operating value.

If the train speed continues to decrease on the grade, more amperes (current) will go through the motors because their resistance decreases as they go slower. If the train speed does not go below the minimum speed for its particular gear ratio, the motors will not overheat, but if the speed does go below the minimum, the train tonnage should be reduced.

105. Reversing the locomotive direction is accomplished by reversing the direction of the current flow in the field windings of the traction motors while the current through the armature continues in the same direction. The change is made by a reverser drum in each unit, operated by remote control from the engineer's control stand. (See Art. 619).

106. Auxiliary equipment. Auxiliary equipment in the F3 locomotive is driven entirely by direct drive from the Diesel engine or by separate electric motors. No belts are used in the locomotive.

107. A 10KW auxiliary generator is directly driven from the Diesel engine. It produces direct current at approximately 74 volts to charge the storage battery and supply the low voltage circuits for lighting, control, generator field excitation, fuel pump operation, etc. (See Art. 609).

The air compressor is driven, through a flexible coupling, from the main shaft of the diesel engine. It is a three cylinder, two stage compressor (See Art. 800).

108. A blower is provided for each traction motor. The blowers are driven by alternating current motors and are mounted in the car body, supplying cooling air to the traction motors through passages in the floor which connects with ducts in the truck assemblies. The fans which draw air through the engine cooling water radiators are also motor driven. Their operation is controlled by the temperature of the engine cooling water (see Art. 301).

109. **Dynamic Braking** (If used)

The dynamic brake feature of the F3 locomotive retards the train on descending grades. When the dynamic brake is in use, electrical circuits are set up which convert the motors into generators. The push of the train against the locomotive drawbar causes the locomotive wheels to drive the traction motors as generators. The electricity produced is dissipated in grids cooled by motor driven fans, located near the top of the car body. Since this generation of electricity requires power, the locomotive holds back against the train and exerts what may be called "negative tractive effort." A rough analogy may be made between dynamic braking and the effect of using second or low gear when descending a steep hill in an automobile. (Refer to Arts. 155 and 642).

OPERATING CONTROLS

110. Three levers and the two brake valve handles conveniently located at the engineer's station control the entire operation of the locomotive. These are the Throttle, Reverse, and Transition levers, which are mounted in the control stand, and the independent and automatic brake valve handles. The controls are simple and easy to operate and are as nearly foolproof as is mechanically possible.

111. **Throttle Lever**

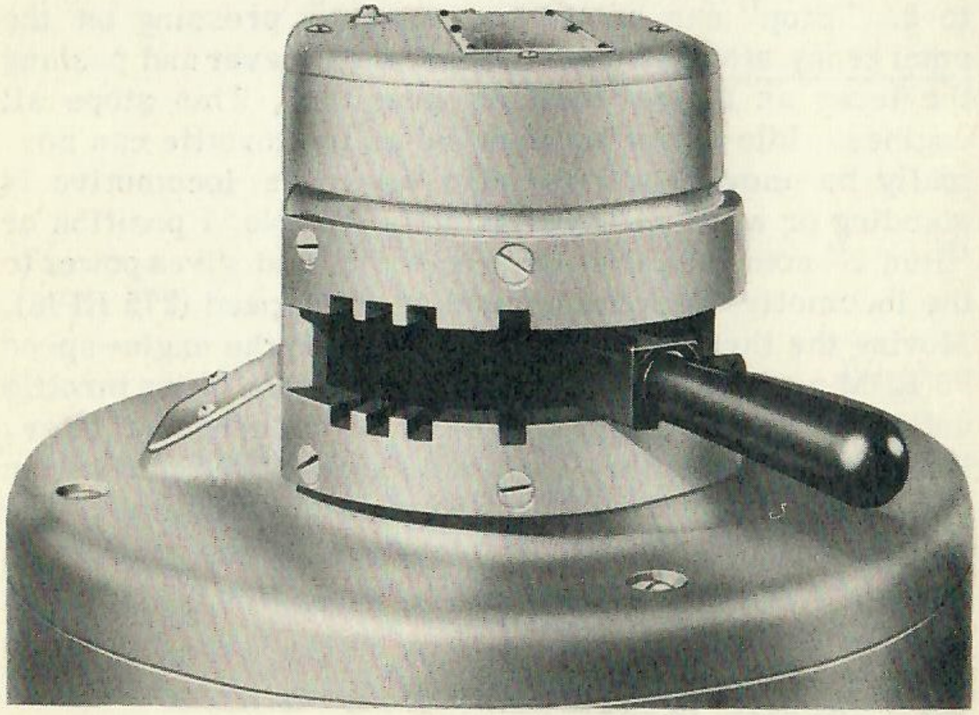
This lever controls the speed of the engines in normal operation, and can also be used to shut down all the engines in an emergency. The position of the lever is shown in the illuminated indicator above the lever. The throttle has 10 positions "Stop," "Idle," and speeds 1 to 8. "Stop" can be obtained only by pressing on the emergency stop button on the end of the lever and pushing the lever as far forward as possible. This stops all engines. Idle is as far forward as the throttle can normally be moved and is used when the locomotive is standing or when no power is desired. No. 1 position or "Run 1" connects the power circuits and gives power to the locomotive with the engines at idle speed (275 RPM). Moving the throttle to "Run 2" advances the engine speed 75 RPM as does each additional movement of the throttle until 800 RPM is obtained in "Run 8." Mechanical interlocks prevent the throttle from being opened more than one notch at a time to prevent rough handling. The throttle may be closed completely with one motion but should be closed only one notch at a time except in an emergency.

112. **Reverse Lever**

The reverse lever must be moved only when the locomotive is standing still. Direction of the locomotive is controlled by movement to the forward or reverse position. In neutral the power circuits will not close. The reverse lever can be removed in the neutral position, which locks all three operating controls. The reverse lever should be removed whenever the engineer leaves his station. (See Art. 114 and 210.)

113. **Transition Lever**

This lever is on the left side of the control stand. Its position is shown in an illuminated indicator in the control stand. The lever controls the "Hookup" of the traction motors. Its use may be roughly compared to the use of the reverse lever on a steam locomotive in "Hooking up," the valve mechanism with variations in speed to obtain best power. The locomotive is started



Transition Lever and Sectors
Fig. 1-2

with the transition lever in No. 1 position and is advanced as the speed increases according to the indications of the Transition and Load Indicating Meter on the instrument panel. In the same manner, as the speed decreases on a grade, the transition lever is returned from position to position as the transition meter indicates. On locomotives equipped with automatic transition the transition lever is not used to effect changes in the traction motor hookup.

When transition lever is moved to "OFF" position, the braking contactors are closed and the cam switch is moved to "TOW" position, establishing the braking circuit. When the lever is moved to "B" position, the battery field contactor closes, exciting the fields of #1 main generator. As the lever is moved farther to the right of "B" excitation is increased, increasing the braking effort. The degree of application is gauged by observing the pointer on the load and transition incicating meter. (See further information under Art. 155.)

114. **Mechanical Interlocks on the Controller**

The levers on the controller are interlocked so that:

1. The reverse lever can be operated only with the transition lever in either No. 1 or "OFF" position and throttle at "IDLE."
2. The reverse lever can be removed from the controller only with the transition lever in "OFF" position and throttle at "IDLE."
3. The throttle can be moved to "STOP" with any position of transition or reverse levers.
4. The transition lever cannot be moved from 2 to 3 position or 3 to 2 position with the throttle in the 7th or 8th position.

INSTRUMENT PANEL

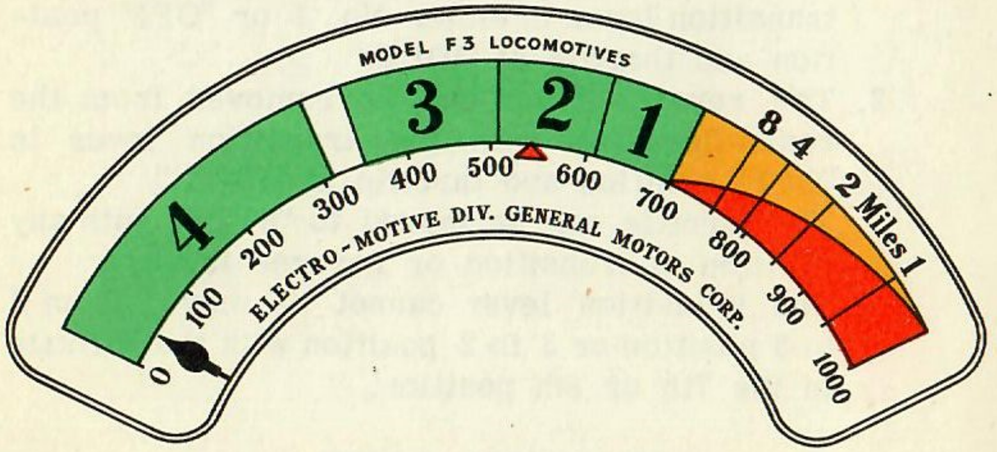
115. The instrument panel contains gauges and lights to guide the engineman in the operation of the locomotive.

116. **Air Gauges**

These are standard gauges. Each gauge is clearly labeled as to its function.

117. **Transition and Load Indicating Meter**

This meter is an accurate guide to the load on the locomotive. It should be constantly observed so that transition may be made at the proper time and overloading of the equipment avoided. The operating range of the locomotive is colored green while the overload area is red. The numbered areas 1, 2, 3, 4 indicate the position in which the transition lever should be placed when operating in Manual Transition. The transition lever should be changed immediately whenever the needle crosses the line from one area to the next so that the transition lever position corresponds with the number in the area to which the needle is pointing. This is imperative on decreasing speeds to prevent overloading and is desirable on increasing speeds for best acceleration. The lever should be in No. 1 position for automatic transition operation. When automatic transition is used it is well for the engineer to note that transitions are being made properly, especially on the downward transition from 3 to 2 (the wheel slip light will flash as each unit changes from 2 to 3 or 3 to 2). If the locomotive is operated with the needle in the "Red," overload ratings (see Art. 201) must be observed.



Transition and Load Indicating Meter
Fig. 1-3

A small red triangle indicates the maximum amount of current in Dynamic brake that may safely be used.

118. **Wheel Slip Light**

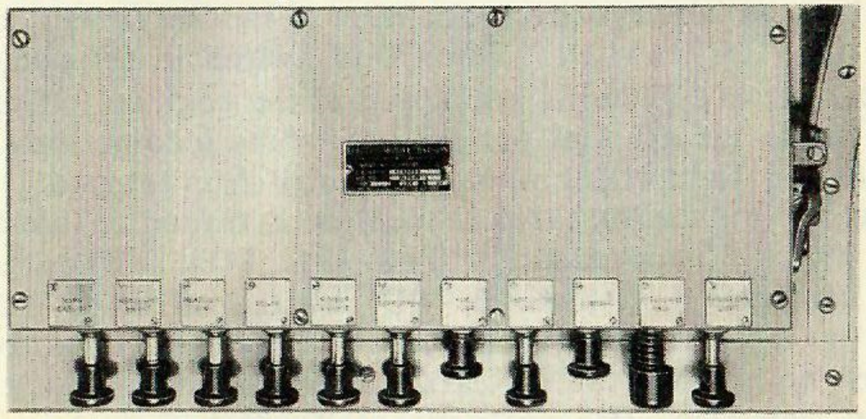
This light indicates that the locomotive wheels are slipping, and the throttle should be reduced one or more notches to stop the Slipping (see Art. 636).

119. **Dynamic Brake Warning Light** (If Used)

If the dynamic brake in any of the units is overloaded this light will serve to indicate that the brake should be reduced (see Arts. 155 and 724).

SWITCHES

120. The engineer's control push-button box is located above the side window at the Engineer's station. It contains switches for control, light and accessory circuits which the engineer may need during operation. The switches are clearly labeled.



Engineer's Control Push-Button Switch Box
Fig. 1-4

1. Engineers light - for light at engineer's station.
2. Attendant call - rings alarm bells throughout locomotive for engineer to call attendant.

3. Control 4. Gen. Field 5. Fuel pump	These three must be closed whenever locomotive is to be operated to provide control, power, and fuel in all units

6. Defroster
7. Number - Locomotive number lights, and ground lights
8. Class lights
9. Headlight dim
10. Headlight bright - closed in addition to dim switch for bright light.
11. Mars light.

The distribution panel located on the right side of the electrical control panel in the engine room has a number of main switches all of which are to be closed during normal operation. (See Fig. 7-7C).

121. PC Switch

The pneumatic control switch (PC) is an air operated electric switch. This switch is tripped by any "penalty" application of the air brakes. On most locomotives an emergency application of the brake will also trip the "PC" switch. When this switch is tripped, it automatically reduces the speed of the engines to Run 1 and shuts off all fuel pumps. On some locomotives an indicating light will show when the switch is tripped. To reset the switch the throttle must be returned to idle and the brake "recovered." (See Art. 218). When this has been accomplished the "PC" switch will reset itself and the indicating light will go out. On those locomotives which do not have an indicating light the switch must be reset manually. (Manually operated switches are beneath the cab window, the automatic "PC" switch is in the nose.)

AIR BRAKE EQUIPMENT

122. The No. 24 RL brake equipment is normally used on

the F3 locomotives. The details of this equipment are specified by the railroads to meet their particular operating requirements and vary from road to road. The air brake gauges are located on the instrument panel in front of the engineman. For full description, see manufacturer's instruction books covering this equipment.

In general, the cab equipment consists of the automatic brake valve, the independent brake valve and the K-2-A Rotair valve, a manually operated valve having four positions and located to the right of the controller as shown in Fig. 1-1.

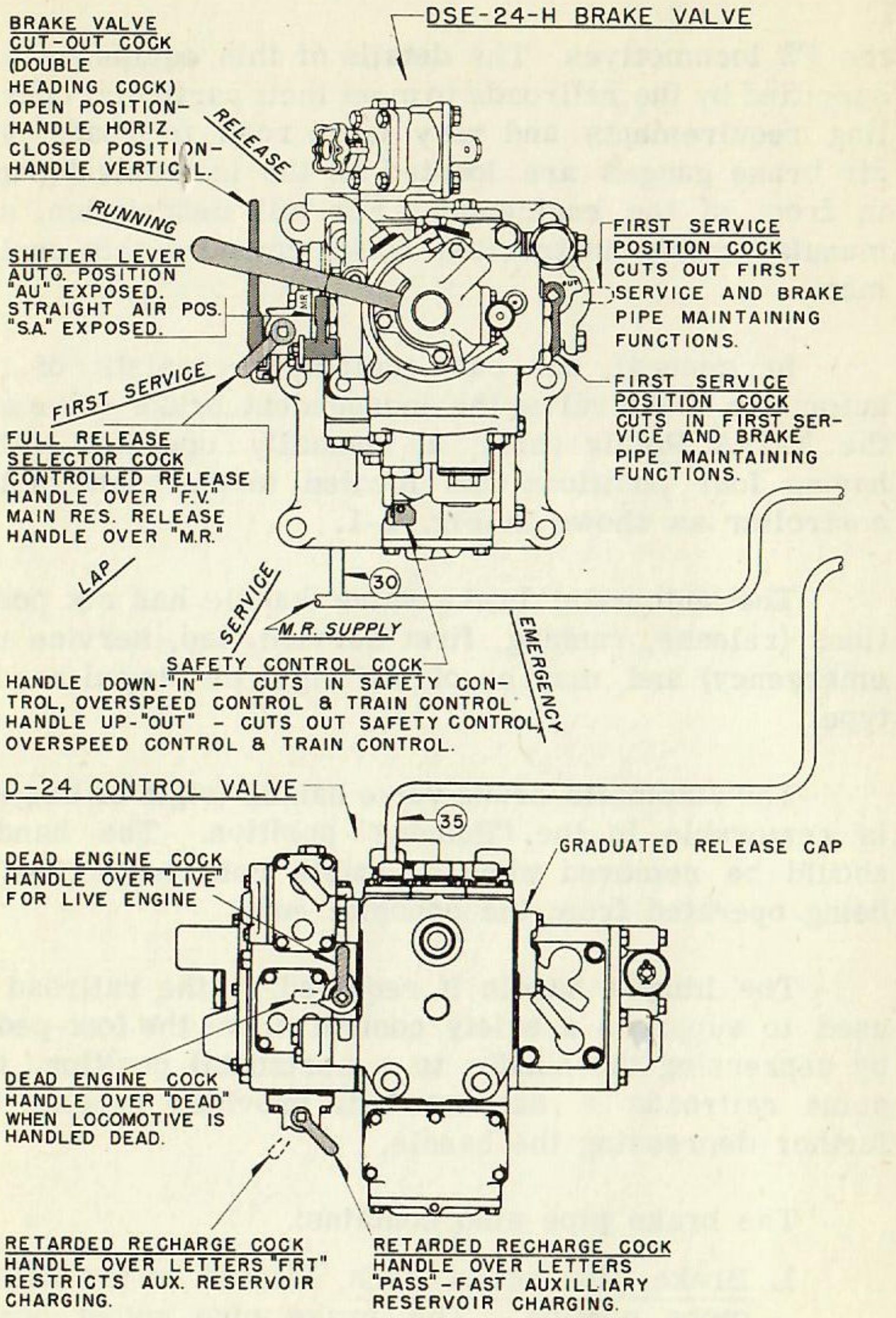
The automatic brake valve handle has six positions (release, running, first service, lap, service and emergency) and may be of the rigid or hinged handle type.

The automatic brake valve handle (rigid or hinged) is removable in the "Running" position. The handle should be removed when a double cab locomotive is being operated from the opposite end.

The hinged handle if required by the railroad is used to suppress a safety control from the foot-pedal by depressing the handle to a horizontal position. On some railroads a sanding bail provides sanding by further depressing the handle.

The brake pipe also contains:

1. Brake pipe cutout cock, located on the filling piece portion. The brake pipe cutout cock, which is located on the filling piece portion of the automatic brake valve, is used for cutting out the brake valve. When the handle is pointing forward ("Live" position,) the brake valve is cut in.



BRAKE VALVE CUT-OUT COCK (DOUBLE HEADING COCK) OPEN POSITION-HANDLE HORIZ. CLOSED POSITION-HANDLE VERTICAL.

SHIFTER LEVER AUTO. POSITION "AU" EXPOSED. STRAIGHT AIR POS. "S.A." EXPOSED.

FIRST SERVICE POSITION COCK CUTS OUT FIRST SERVICE AND BRAKE PIPE MAINTAINING FUNCTIONS.

FIRST SERVICE POSITION COCK CUTS IN FIRST SERVICE AND BRAKE PIPE MAINTAINING FUNCTIONS.

FULL RELEASE SELECTOR COCK CONTROLLED RELEASE HANDLE OVER "F.V." MAIN RES. RELEASE HANDLE OVER "M.R."

SAFETY CONTROL COCK HANDLE DOWN-"IN" - CUTS IN SAFETY CONTROL, OVERSPEED CONTROL & TRAIN CONTROL. HANDLE UP-"OUT" - CUTS OUT SAFETY CONTROL, OVERSPEED CONTROL & TRAIN CONTROL.

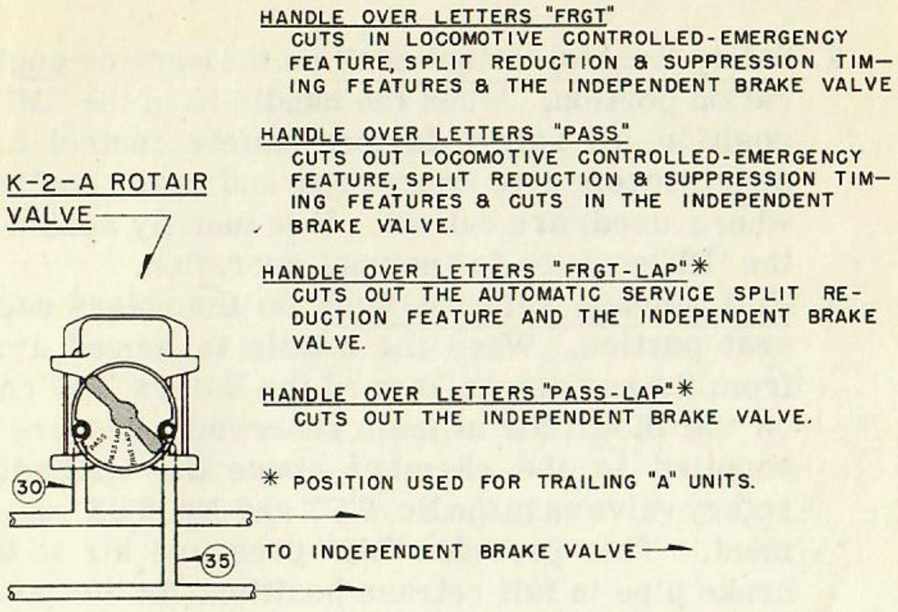
DEAD ENGINE COCK HANDLE OVER "LIVE" FOR LIVE ENGINE

DEAD ENGINE COCK HANDLE OVER "DEAD" WHEN LOCOMOTIVE IS HANDLED DEAD.

RETARDED RECHARGE COCK HANDLE OVER LETTERS "FRT" RESTRICTS AUX. RESERVOIR CHARGING.

RETARDED RECHARGE COCK HANDLE OVER LETTERS "PASS"-FAST AUXILIARY RESERVOIR CHARGING.

Fig. 1-5



HANDLE OVER LETTERS "FRGT" CUTS IN LOCOMOTIVE CONTROLLED-EMERGENCY FEATURE, SPLIT REDUCTION & SUPPRESSION TIMING FEATURES & THE INDEPENDENT BRAKE VALVE

HANDLE OVER LETTERS "PASS" CUTS OUT LOCOMOTIVE CONTROLLED-EMERGENCY FEATURE, SPLIT REDUCTION & SUPPRESSION TIMING FEATURES & CUTS IN THE INDEPENDENT BRAKE VALVE.

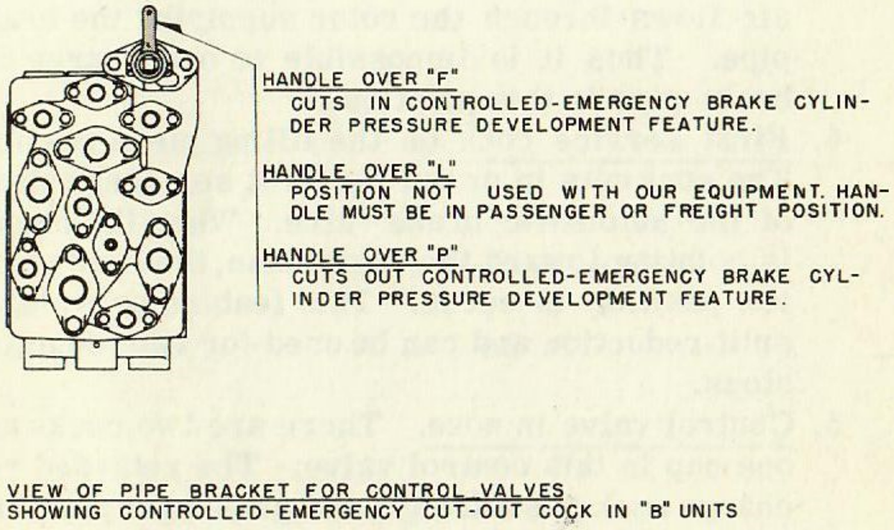
HANDLE OVER LETTERS "FRGT-LAP"* CUTS OUT THE AUTOMATIC SERVICE SPLIT REDUCTION FEATURE AND THE INDEPENDENT BRAKE VALVE.

HANDLE OVER LETTERS "PASS-LAP"* CUTS OUT THE INDEPENDENT BRAKE VALVE.

* POSITION USED FOR TRAILING "A" UNITS.

TO INDEPENDENT BRAKE VALVE →

o



HANDLE OVER "F" CUTS IN CONTROLLED-EMERGENCY BRAKE CYLINDER PRESSURE DEVELOPMENT FEATURE.

HANDLE OVER "L" POSITION NOT USED WITH OUR EQUIPMENT. HANDLE MUST BE IN PASSENGER OR FREIGHT POSITION.

HANDLE OVER "P" CUTS OUT CONTROLLED-EMERGENCY BRAKE CYLINDER PRESSURE DEVELOPMENT FEATURE.

VIEW OF PIPE BRACKET FOR CONTROL VALVES SHOWING CONTROLLED-EMERGENCY CUT-OUT COCK IN "B" UNITS

Cock Handle Positions
24RL Brake
All Types of Service
Fig. 1-5

2. Safety control cutout cock on the service application portion. When the handle is in the "OUT" position, all safety devices (safety control foot pedal, locomotive overspeed and train control, where used) are cut out. It is usually sealed in the "IN" position for normal operation.
3. Full release selector cock on the rotary valve seat portion. When the handle is moved away from the engineman, toward the letters "MR" cast on the block, air at main reservoir pressure is supplied to the chamber above the automatic rotary valve as in the No. 6 ET and No. 8 ET equipment. This provides "MR" pressure air to the brake pipe in full release position. In this position overcharging the brake pipe is possible. When the selector cock is moved to the "FV" position (handle pointing toward engineman), feed valve regulated air pressure is admitted to top of brake valve rotor. With brake valve handle in full release position, feed valve regulated air flows through the rotor supplying the brake pipe. Thus it is impossible to overcharge the brake pipe in this position.
4. First service cock on the filling piece portion. The cock cuts in or out the first service position of the automatic brake valve. When the handle is pointing toward the engineman, the first service position is cut in. This feature provides a split reduction and can be used for two reduction stops.
5. Control valve in nose. There are two cocks and one cap in this control valve. The retarded recharge cock has a freight and passenger position. When in "Freight" position, charging of pressure chamber is slow, which provides retarded release. When it is in "Passenger" position, charging is fast, which provides accelerated release. The Dead Engine cock will be closed (LIVE) position) in normal operation and open (DEAD position) in case locomotive is being hauled dead in the train. The graduated release cap, situated in the side of the control valve, has two settings, "Graduated" and "Direct." This applies to independent release which will usually be graduated in passenger trains and direct in freight trains.

123. **Independent Brake Valve**

The S-40-F independent brake valve handle has two positions - "Release" and "Full Application" - with the "Application Zone" between the two positions. The brake valve is of the self-lapping type which automatically laps off the flow of air and maintains it when the applied pressure reaches the value corresponding to the position of the brake valve handle in the application zone. Release of locomotive brakes after automatic application is obtained by depressing the brake valve handle.

124. **K-2-A Rotair Valve**

The four positions of the K-2-A Rotair valve are "FRGHT," "FRGHT LAP," "PASS LAP" AND "PASS." See "OPERATION" for handling of this valve.

125. **Safety Control Foot Pedal**

The safety control foot pedal is located in the front of the engineman's seat. On locomotives equipped with the DS-24-H Brake Valve, having the hinged automatic brake valve handle, the handle provides an alternate control when it is depressed sufficient to contact the sanding bail. Either the pedal or the automatic brake valve handle must be kept depressed at all times except when the locomotive is stopped and the locomotive brakes are applied (30 lbs. or more brake cylinder pressure). If both the foot pedal and the automatic brake valve handle are released at the same time, a full service application of the brakes will result.

MISCELLANEOUS EQUIPMENT

127. Sanding Valve (See Art. 805).

When the locomotive is equipped with the hinged automatic brake valve handle, sanding is accomplished by depressing the lever beyond its safety control position previously described. This movement operates the sanding bail which opens a port to supply air to the sanding equipment. On locomotives having a rigid handle on the automatic brake valve, an independent sanding valve is installed. This lever is operated by pushing the lever forward.

Sanding in emergency, which is provided in some railroads, is automatic with any emergency application.

128. Speed Recorder—Locomotive Overspeed Control

The speed recorder, located in front of the control stand is a hydraulically operated speed indicator with a speed recording tape and an odometer. It is driven from the No. 1 axle of the "A" unit, through a flexible cable. It contains a maximum speed device which will initiate a full service application of the brakes and trip the PC switch if the maximum speed setting is exceeded.

129. Unit Selector Switch (Dynamic Brake)(See Art. 762)

The unit selector switch located next to the engineer's instrument panel has four positions and should be set corresponding to the number of units making up the locomotive. The unit selector switch should be set before leaving the maintenance point and when isolating an engine en route, this switch must not be changed.

130. Windshield Wipers

The speed of each wiper is controlled independently by a needle valve, which also turns the wiper on and off. One is located in the engineman's instrument panel and one on the panel on the fireman's side of the cab. The wipers should not be run on a dry window as dirt on the glass or blade will scratch the glass. The windshield wipers, horn, bells and sanders are supplied by air which comes through a filter common to all.

131. Horn Valves

The horns are operated by air valves which are controlled by pull-cords, above the control stand. One horn is directed to the front of the train (right hand pull-cord) and the other to the rear of the train. The horn shut off valve is located in the front of the No. 2 Main Reservoir.

132. Locomotive Bell Valve

The locomotive signal bell is under the locomotive floor behind the pilot on the left side. It is operated by an air valve located at the engineer's station. This bell should not be confused with the alarm bell which is an electrical device. The bell shut off valve is located to the left side of the front end of the No. 2 Main Reservoir.

133. Cab Heaters

A cab heater is located on each side of the cab. Hot water from the engine cooling water system passes through the heaters and motor driven fans provide circulation. The flow of water to both heaters is controlled by a valve in the supply line, located over the left-hand engine room steps. This valve must be kept wide open at all times in freezing weather. The output of each heater can be varied by use of the cab heater motor switches. The switches have four positions "OFF," "1," "2," and "3" which provide three different motor speeds. If the lead unit is isolated in freezing weather steam may be admitted to the cab heaters. (See Art. 308).

134. **Defrosters**

Each side of the cab is equipped with a defroster motor and fan which blows heater air on the inside of the front cab windows. Both motors are turned on and off by the defroster switch in the control push-button switch box.

135. **Classification Lights**

A permanently fixed, clear glass bull's-eye lens is provided on each side of the nose. Inside the nose and behind each bull's-eye, a small compartment contains the classification light bulb and colored lenses. Red and green lenses are provided in each compartment which can be moved into a position between the bulb and the bull's-eye. To accomplish this, a locking pin is removed, the desired lens swung into place and the locking pin replaced. The lenses are accessible from the inside of the nose section through hinged doors in the compartments. When both red and green lenses are out of position the permanent bull's-eye lens will show a white light, thus making three colors available.

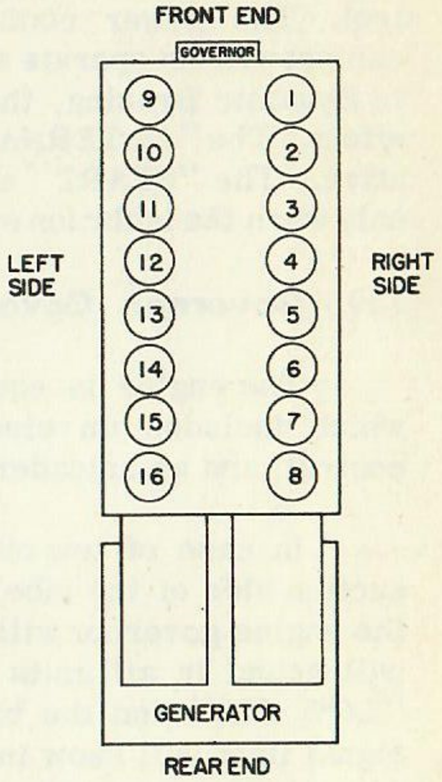
ENGINE ROOM

136. The two ends of the engine are designated "FRONT" and "REAR" as shown in the accompanying sketch. However the engine is placed so that its rear end is toward the front end of the unit when the unit is operating in its normally forward direction.

A cylinder test valve is provided for each cylinder.

The test valves are opened to check for the possible presence of water in the cylinders when starting the engine after a layover.

The accompanying sketch serves to identify the cylinder locations, ends and sides of the engine, as they are referred to in this manual. The governor, water pumps, and lubricating oil pumps are mounted on the "FRONT END." The blowers, oil separator and generator are mounted on the "REAR END."



137. **Engine Control and Instrument Panel**

This panel is mounted on a frame which supports the engine cooling water tank near the governor end of the engine. Each power plant has its own engine control and instrument panel on which are mounted the lube oil pressure and suction gauges, fuel tank gauge, Start, Stop, Fuel pump, and Isolation switches.

138. **Isolation Switch**

The switch has two positions - "START" (handle pointing horizontally) and "RUN" (handle pointing down vertically). With the switch in "START" position the power plant is disconnected from those in the other units and is said to be "isolated." The engine will remain at idling speed and will not respond to throttle control. The power contactors in the electrical control cabinet will not operate when the transition lever is moved. In Dynamic Braking, the unit will exert no retarding effect. The "ALTERNATOR FAILURE" alarm is inoperative. The "START" and "STOP" buttons are effective only when the isolation switch is in the "START" position.

139. **Governor, Governor Speed, Safety Control**

The engine is equipped with a Woodward Governor which includes an electro-hydraulic governor speed control, and an unloader used during transition.

In case of low oil pressure or high vacuum on the suction side of the lube oil and piston cooling oil pumps, the engine governor will stop the engine. The alarm bells will sound in all units of the locomotive. The yellow "LOW OIL" and the blue "ALTERNATOR FAILURE" signal light will show in the unit concerned.

When the governor safety control stops the engine, a push-button on the front of the governor housing moves out approximately 3/8" exposing a red band around the shaft of the button. The governor reset push-button must be pressed in to put out the "LOW OIL" alarm lights and the isolation switch moved to "START" position to cut out the "ALTERNATOR FAILURE" alarm lights. Both actions are necessary to stop alarm bells. (See Art. 404).

The push-button will not trip if the engine stops due to placing of throttle in emergency stop position, operation of manual layshaft control lever, tripping of ground protective relay when throttle is in Run 5 or Run 6 or use of the "STOP" button for normal shut down. In these

instances, the "LOW OIL" alarm lights will not light but the "ALTERNATOR FAILURE" alarm will function (except when the "STOP" button is used) to serve as a warning that an engine is stopped.

When the engine is stopped by governor control action, the push-button must be reset before the engine can be started. When the engine is started and run at idling speed, the governor will stop the engine again after approximately 40 seconds, if the condition still exists which caused the original shutdown. This time delay is provided to allow a check to determine the cause of the shutdown. However, if an attempt is made to run the engine above idling speed during the delay period, the governor will stop the engine at once should the oil pressure be low or the oil pump suction be high.

140. **Electrical Control Cabinet**

The electrical control cabinet contains the various contactors, relays and other equipment necessary for the electrical and electro-pneumatic control of the unit. Units of the electrical system are listed in Section 7.

141. **Control Air Pressure Regulator** (See Art. 802)

The power contactors, reverser and cam-switch in the electrical control cabinet are operated by air pressure supplied through magnet valves which are controlled from the cab. The "control air" is supplied from the main reservoir, and reduced to 80 pounds pressure by the control air pressure regulator. The pressure is indicated on a gauge in the electrical control cabinet.

142. **Load Regulator**

The load regulator is a device which loads each engine according to the throttle setting in the cab. It automatically maintains a constant horsepower output, corresponding to each throttle position, over the entire range of locomotive speeds. In normal operation the load regulators in all units should be in approximately the same position. (See Arts. 227 and 627).

143. **Layshaft Manual Control Lever**

The layshaft manual control lever is attached to the end of the injector layshaft, and if necessary, may be used to shut the engine down manually or bring the engine speed to idle as when taking an engine "off the line."

144. **Indicators, Gauges and Protective Devices**

The entire operation of the locomotive may be conducted from the cab. Protective devices, alarm bells, and signal lights are installed in the locomotive to provide the maximum protection for the equipment. Although the operation of the equipment in the engine room is automatic it is good practice to observe conditions in the engine room at frequent intervals to be sure that the mechanism is functioning properly.

There are a number of indicators, gauges, and protective devices which should be observed when inspecting the engine room. (See Art. 148, item B3).

Additional protective devices and indicators are installed in the locomotive which should be checked when abnormal operation ("trouble") is encountered (See Arts. 212, 213 and 214.)

145. **Engine Overspeed Trip**

If the engine speed exceeds approximately 910 RPM, an engine overspeed device will trip and bring the engine

to a stop. (See Art. 506).

146. **Hand Brake** (if used)

The hand brake wheel is located in the engine room, to the right of the air compressors of both the "A" and "B" units. To set brakes with foot pedal hold foot pedal down and turn the wheel. To release the brake, advance the wheel enough to release the foot pedal latch and then let go of the wheel. On brakes without foot pedal rotate wheel in release direction against the friction locks. Before moving the locomotive, be sure the brakes are completely released. Whenever anyone is working around the locomotive trucks, the handbrakes should be applied.

NORMAL OPERATION

147. Operation of the F3 locomotive is very simple and if the procedures given here are followed no difficulty should be encountered. A very important factor in keeping difficulties and resulting delays to a minimum is the checking of the locomotive equipment before attempting to operate the locomotive to be certain that everything is in good order. Do not skip items or perform a check that is not thorough as the item that is missed or carelessly checked is sometimes the cause of long delays.

NOTE: The following operating conditions pertain to manual transition unless otherwise stated.

PRELIMINARY

148. **When Boarding the Locomotive**

A. Inspect exterior of locomotive and running gear for:
  1. Liquids leaking from the locomotive.
  2. Loose parts
  3. Proper positioning of Angle Cocks and Shut

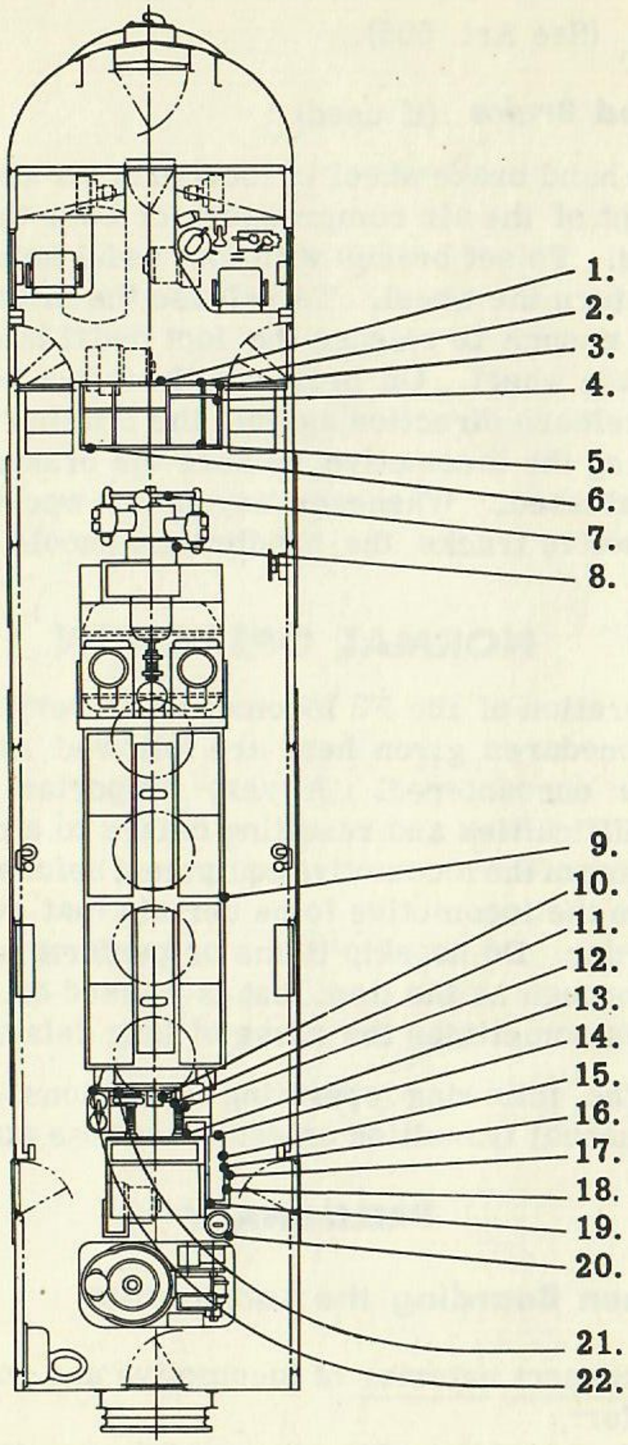


Fig. 1-6

ENGINE ROOM CHECK CHART

Fig. 1-6

	Item	Reading		Ref. Art. No.	Unit Failure Check
		Idle	800 RPM		
1.	Aux. Gen. Ammeter	20	20+	220	B
2.	Starting Contactors	Not Stuck		221	X
3.	Control Air Pressure	80 ± 3		222	X
4.	Battery Ammeter	0 or +	0 or +		
5.	Ground Relay	Yellow		224	X
6.	Main Reservoir	130 to 140			
7.	Air Comp. Intercooler	30# When Pumping		800	
8.	Air Comp. Oil Pres.	5#	15#	800	

FAILURE CHECK. Should a unit fail to perform properly check items lettered as "X." The letters R, B, YB, indicate items that will cause Red, Blue, or Yellow and Blue lights to come on. See Art. 212 for details.

9.	Lube Oil Level	Run Level		401	
10.	Eng. Speed & Fuel Ind	Both Needles Correspond		225	X
11.	Gov. Oil Level	Between Lines			
12.	Water Pressure	0 to 5	25 to 35		R
13.	Water Temperature	125° Min.	$165^{\circ} \pm 15^{\circ}$	301	R
14.	Isolation Switch	"RUN"		226	X
15.	Lube Oil Pressure	6# Min.	30# to 45#	139	YB
16.	Fuel Quantity	As Needed			
17.	Load Regulator	Same as other units		227	X
18.	Lube Oil Suction	Green		139	YB
19.	Water Level	Between Lines		303	R
20.	Gen. Water Supply	As Needed			
21.	Overspeed Trip	Latched (Pull to Set)		229	B
22.	Fuel Flow	Thru Glass Nearer Engine		228	X

Location of gauges, relays and equipment
Fig. 1-6

Off Valves.

B. In the Engine Room, with engines running (if dead see Art. 208).
  1. Check for oil, water, and fuel leaks.
  2. Release hand brake. (Check Air Brake.)
  3. Check gauges, indicators switches as listed in Fig. 1-6.
  4. Check transition cut-out switches. They should be pinned or sealed in the position in which the locomotive is to be operated — either all in automatic or all in manual.

C. In the Cab.
  1. Install Brake Valve handles - set independent brakes.
  2. Check brake valve cut-out cock and rotair valve position ("FRGHT" or "PASS" as desired - "PASS" recommended for running light).
  3. Push in "Control," "Fuel pump" and "Generator Field" switches.
  4. Check to see that "PC" switch is set.
  5. Install reverser handle, move to "forward" or "reverse."
  6. Place manual transition lever in No. 1 position. (To move transition lever, lift as high as it will go, press firmly in direction you desire to move the lever. Maintain this side pressure and lower the lever, it will slip into next notch.)
  7. For operation with automatic transition, see Art. 156.
  8. Check position of dynamic brake selector switch, to correspond with number of units of locomotive.

149. Maneuvering

A. Running light (Complete cab preparation Art. 148, Item C3).
  1. Place foot on safety control foot pedal.
  2. Release independent brake.

  3. Open throttle one notch at a time. (To open throttle jerk it gently to the next notch and release. This will permit the lever to set itself for the next notch.)
  4. NOTE THAT THE LOCOMOTIVE ROLLS FREELY AND CARE SHOULD BE USED IN JUDGING ITS SPEED.
  5. Close throttle to idle before setting brake.
  6. Locomotive MUST be standing still at the time the reverse lever is moved.

B. Coupling to train.
  7. Locomotive must not be moved with air hoses hanging free on nose of "A" units.
  8. In backing onto a train it may be desirable to use the attendants call in rear "A" unit or train signal whistle valves in "B" units for signalling.
  9. Valves and cocks.
    a. Nose angle cock is behind pilot on fireman's side.
    b. Steam line valve behind pilot on engineman's side (Plate must be removed to connect Steam Line).
    c. Train line signal whistle shut off in nose compartment directly ahead of engineman. It is on signal line reducing valve at front center of brake rack.

C. Pumping up air.
  1. Pull out generator field switch.
  2. Place reverser in neutral.
  3. Open throttle to 3rd, 4th or 5th notch as needed.

150. Splitting and Joining Units

  1. Take down all jumpers (inside and outside the diaphragm.
  2. Close angle cocks on both units on all jumper hoses.
  3. Break hoses and separate units.

4. In joining units.
   a. Connect hoses and jumpers and BE SURE THE ANGLE COCKS ON ALL JUMPER HOSES ARE OPENED IN BOTH UNITS.
   b. Cut out brakes and control in all but one unit. Remove reverse lever in trailing units.

HANDLING A TRAIN

151. **Starting** (Recheck cab preparations, Art. 148, Item C)

FREIGHT

1. Place foot on safety control foot pedal and release brakes.
2. Open throttle one notch every 1 to 2 seconds as follows:
   a. To No. 1 position - note load indicating meter move.
   b. To No. 2 position - note engine speed increase.
   c. To No. 3 or higher until locomotive moves. (It is usually unnecessary to go above the 4th notch).
   d. Throttle may be eased off 1 or more notches if acceleration is too rapid.
   e. When train is stretched, throttle may be opened to any desired position.
   f. If wheels slip, close throttle one notch or more until wheel slip light goes out.
3. It should not be necessary to bunch slack. If slack is bunched great care must be used or couplers may be damaged. Do not go beyond the 4th notch with a four unit locomotive or the 5th notch with less units to start a train unless it is absolutely certain all brakes are released.

Actual tests on 100 car trains have shown that as much as nine minutes may be required to completely release the brakes, although this is an unusual condition. Damaged couplers may result from haste.

Sanding should be done sparingly as sand is harmful to traction motors. Never sand while the wheel slip light is lit. (See Art. 127, 805.)

PASSENGER

In starting passenger trains it is necessary to consider the weight of the train, the amount of slack, the condition of the rail and the demands of the schedule.

Locomotives, when delivered, are adjusted so that the build up of power output is controlled by the load regulator rather than by the throttle. Thus, although the throttle lever is opened rapidly; the rate of power build up will be controlled by the load regulator and a smooth start assured.

To start a passenger train the throttle is opened to whatever position is desired to give the necessary power to start the train; the load regulator will then control the power build up to give a smooth rapid train start.

The throttle position required for the desired start will vary from station to station and likewise from train to train.

Care must be exercised to consider rail conditions to prevent wheel slippage.

Experience will indicate the throttle position, sanding (use sparingly), and throttle manipulation required for each start to meet individual conditions.

The following factors are to be considered:

1. Open the throttle rapidly to the desired position (open quickly to Run 3), then hesitate approxi-

mately 1 to 2 seconds between each notch above 3.

2. Open the throttle to a position high enough that the load indicating meter pointer is still moving steadily to the right at the moment the wheels start to turn. It is desirable to keep the time between the first movement of the throttle and train starting to a minimum.
3. A throttle position that will give a full scale build up during starting may be used if rail conditions will permit.
4. It is permissible to hold the load meter hand to full scale reading after starting by opening the throttle as necessary. This may be used to obtain rapid acceleration if rail conditions permit. After the throttle is opened to the desired position the load meter hand must move steadily to the left until the amperage falls within the continuous rating limits or damage from overloading will result. (See Art. 201.)

152. **Accelerating a Train** (Manual Transition)

1. After the throttle is in the 8th notch the load indicating meter needle should move slowly toward the left. If the needle is in the red area it must continue to move until it is in the green area or the locomotive is overloaded. Operation in the "red" can continue for only a short time (see Art. 201). If the cause is not removed within the specified mileage the train must be stopped or serious damage will result.
2. If the train continues to accelerate the needle on the load indicating meter will cross the black line from area No. 1 to area No. 2. When this occurs the manual transition lever may be moved from No. 1 to No. 2 position. The lever may again be advanced when the needle crosses the line into Area No. 3 and again for area No. 4. Do not advance the transition lever when the needle moves to the left when closing throttle. (How to move transition lever, Art. 148, Item C6).

153. **Slowing Down on a Grade**

1. As the train slows down on a grade the needle on the load indicating meter will move slowly toward the right. As the needle moves across the black line from one area to the next the transition lever must immediately be moved to the corresponding position. When transferring from 2 to 3 or 3 to 2 throttle should be reduced to Run 6. After transition has been made, throttle is opened again to Run 8.

BRAKING

154. **Air Braking with Power**

Under certain conditions it may be desirable to keep the train stretched during a slow down or stop. If this is done the throttle should be closed to at least the 6th notch and the independent brake kept fully released. As the train speed decreases, the throttle must be eased off. As the train slows down, the pulling power of the locomotive increases rapidly and might become great enough to part the train if the throttle is not reduced. The throttle should be in "idle" before the locomotive comes to a dead stop. The load indicating meter must be watched and the transition lever moved as indicated.

155. **Dynamic Braking** (If used)

Dynamic braking is available in either forward or reverse direction. To use the dynamic brake see that the unit selector switch located next to the instrument panel is set to correspond with the number of units in the locomotive consist. Place the throttle in "idle," wait at least 10 seconds, and move the transition lever to "off." (The reverse lever must be in either forward or reverse to operate dynamic brake). If the train is moving at considerable speed enough brake may be present in this position to bunch the slack. If necessary move the lever to "B" and wait until slack is bunched. The Dynamic Brake is in effect an independent brake and the load indicating meter is now acting as a "Brake Cylinder Pressure gauge." The same precautions must be used in controlling slack as with the independent brake of the locomotive. After the slack is bunched the lever may be moved to give the desired amount of brake. The needle must not be carried beyond the red triangle on the load indicating meter nor must the dynamic brake warning light be permitted to stay lit. In either case ease off slightly on the brake until these conditions are remedied.

Differences in idling speed of the engines and variation in the motor and generator characteristics may cause the dynamic brake warning light to come on before the transition meter pointer reaches the red triangle, but in any case, the light must not be on. The light is an indication of an overload, and operating with it "on" might damage the traction motors and braking grids.

The independent brake must be kept fully released at all times when the dynamic brake is in use, or the wheels may slide. As the speed decreases below 10 MPH the dynamic brake becomes less effective. When the speed further decreases it is permissible to completely release the dynamic brake and apply the independent brake simultaneously to prevent the slack from running out.

Whenever desirable the automatic brake may be used in conjunction with the dynamic brake provided that the independent brake is kept fully released.

The most effective use of the Dynamic Brake is between 15 and 25 MPH depending on the gear ratio. Speed on grades should not be allowed to "creep up" by careless handling of the brake as this is a holding brake and is not effective for slowing down heavy trains on steep grades. (See Arts. 109, 113, 642 and 645).

AUTOMATIC TRANSITION

156. Automatic transition became Standard Equipment on EMD locomotives for the purpose of providing a smoother transition, and also to insure transition being made at the proper time, with the throttle in full power or Run 8 position.

It is known by experience that the most reliable and satisfactory means of controlling automatic transition is main generator VOLTAGE for forward transition, and main generator AMPERES for backward transition. There is one exception to this rule. Backward transition from 4 to 3 occurs when the main generator voltage has dropped to the dropout value of the forward transition relay. As this relay drops out, the motor shunting contactors open, bringing the traction motor circuit back to (full parallel) #3 position.

The operation of a locomotive with automatic transition differs from that of a locomotive operating with manual transition only to the extent that transition is made automatically with the throttle in Run 8 position, without any attention of the engineman. This is a great help when leaving a complicated terminal for it requires no attention of the engineman.

As a precautionary measure, before leaving a terminal, the engineman should check the position of the transition cutout switches in all units. By opening the upper right-hand door of the high voltage cabinet, on the left-hand or Fireman's side of the "A" unit, the cutout switch will be found on the lower right-hand side of the relay panel. The panel is plainly marked "MAN" (Manual) to the left side of switch, and "AUTO" (Automatic) to the right side.

A small pin holds this switch in the desired position. The cutout switch on the "B" unit is located in a similar place. The left side of the "B" unit, regardless of direction of movement, is that side opposite to where the engine starting and control panel is located. ALL cutout switches MUST be placed in the same position, either automatic or manual. It is preferable that they be sealed in this position with a wire seal.

On earlier models of the F3 locomotive, a forestalling feature was used to prevent undesired pregression of forward transition. This forestalling feature has now been eliminated from all road locomotives for engineering and operating advantages. With the transition lever in #1 position, transition will occur automatically, and go through each step progressively, either forward or backward as the main generator VOLTAGE or AMPERE output change their respective value, depending on acceleration or deceleration of train. The same will occur regardless of the position of the transition lever, whether in either #1-2-3-4 position. Position #1 is recommended very strongly for reasons cited further on.

However, previous instructions were issued to place the transition lever in #4 position when starting the earlier model locomotive having automatic transition. This operating instruction was desirable on locomotives equipped with the forestalling feature. Since the elimination of the forestalling feature, the operating procedure had to be changed. Today's recommended

method for starting a locomotive set in automatic transition is to place the transition lever in #1 position, and LEAVE IT THERE.

It must be understood, the running gear of the Diesel-Electric locomotive is primarily the same as any other electric locomotive. Electric current, generated by the Diesel engine turning the armature of the main generator is supplied to traction motors which are geared to the axle, turning the driving wheels of the locomotive.

All electric locomotives, including the Diesel-Electric, have a starting characteristic differing from that of the steam locomotive. When starting a heavy train, the traction motors exert a very high starting tractive effort by demanding very high current (amperes) from the main generator. The entire power output of the engine and generator is being forced into the traction motors during starting.

As stated it is true that transition will occur automatically, and go through each step progressively, REGARDLESS of the running position of the transition lever, but if one or more of the transition cutout switches should ACCIDENTALLY be in manual position, and the transition lever placed in position #2-3-4, backward transition will NOT occur on the unit or units which are in manual position, and severe damage to the generator can be expected. In addition, when starting a train under this condition, the unit or units in manual position will immediately assume motor connection called for by transition lever position (#2-3-4) ahead of the others in automatic transition as soon as the throttle is opened. If this should happen to be #3 or #4 position, these traction motors would be TRYING to accelerate the train in either parallel or parallel-shunt. Severe damage to these motors and main generator would be inevitable.

The transition indicator, located in the operating cab, is a very essential part of the electrical equipment, serving as the sole guide for the engineman toward the proper operation of the locomotive in EITHER automatic or manual transition.

The dial or face of the transition indicator has two separate and distinct functions. The right-hand side of the dial, with a red comet marking, is the DANGER, or overload section. The yellow over the red is also caution, for overheating of the motors increases rapidly as the red band becomes wider. This portion of the dial is marked off in miles to which it is permissible to operate in each mileage zone SEPARATELY, but NOT collectively. To the left of the DANGER or overload area is the safe operating section of the dial, colored green, which is marked off into shifting zones for use of the engineman.

As current is applied to the traction motors, in starting a train, the needle of the transition indicator will swing to the right side of the dial, and may go as high as 1000 amperes before the train starts moving. This is a natural condition and should not cause alarm for, as the speed of the train increases, the ampere demand decreases and the needle of the indicator gradually recedes to the green section of the indicator.

While the train speed is increasing, ampere demand of each motor is decreasing, BUT the generator voltage is increasing proportionately. As the needle of the indicator recedes to the left, because of the decrease in current to the motors, it will in time reach the "Shift to Two" line on the indicator. The shifting point is the dividing line between the numbered areas on the green section of the indicator dial. The generator voltage will now be high enough to pick up the forward transition relay, if operating in automatic

transition. When operating in manual transition, the engineman should shift promptly to series-parallel shunt or "Two" when the indicator needle is on this dividing line.

After transition has taken place, and the train speed continues to increase, the needle will again recede to the left, until it reaches the "Shift to Three" line between #2 and #3 areas. The forward transition relay will again pick up at this point if in automatic transition, because the main generator voltage has again reached the pickup value of the relay. The traction motor connections will then be changed from series-parallel-shunt to full parallel, or #3 position. In manual transition, the engineman should promptly reduce the throttle to Run 6, and shift the transition handle to "Three" and immediately reopen throttle to Run 8.

With continuing acceleration, the needle will gradually recede to the left until it reaches the "Shift to Four" position. The forward transition relay again picks up when in automatic transition, because the generator voltage has again reached the pickup value of the relay. The motor connections will now be in parallel-shunt, or #4 position, the final step in motor transition. In manual operation the engineman should place the transition lever in #4 position promptly in the same manner instructed above, but this time leaving the throttle in Run 8.

All of the foregoing deals with FORWARD transition. Now to explain BACKWARD transition. Assume the train is running in #4 transition position, and it reaches an ascending grade. The traction motors will then demand more amperes or current and the generator voltage will start to drop. Under this condition the indicator needle will progress to the right until it reaches the "Shift to Three" position. As the generator voltage drops to the dropout value of the same forward transition relay, the motor circuits will revert back to #3 position automatically. If operating in manual transition position, the engineman should move the transition lever back to #3 position correspondingly and promptly.

With a further decrease in train speed, the ampere demand of the motors continues to increase and the generator voltage continues to drop. As the indicator needle progresses to the right, it will reach the "Shift to Two" position. The current or amperes in the main generator leads have reached the pickup value of the backward transition relay. In automatic transition, this will return the motor connections to series-parallel-shunt, or #2 position. In manual transition, the engineman should again reduce the throttle to Run 6 quickly, shift to "Two" and return the throttle to Run 8. With a little experience the engineman will find he can make this shift with no appreciable loss in train speed.

Further decrease in train speed will again cause the automatic backward transition relay to pick up, bringing the motors back to series-parallel, or #1 position. In manual transition, the engineman should naturally shaft to "One" promptly. This is the lowest step in transition or "low gear" in automobile terminology. The tonnage of the train must be no greater than what the locomotive can pull, without the indicator needle going over into the red or OVERLOAD section, except under certain conditions about to be explained.

There are four short time rating zones in the red overload section of the transition indicator dial, (1) permitting overload operation for eight miles, (2) four miles, (3) two miles and (4) one mile. Remember, separately in any one zone, NOT collectively. It is

permissible to continue with the needle progressing into two or more short time rating zones, ONLY if the total overload mileage does not exceed that of the SHORTEST mileage zone to which the indicator needle has progressed.

If the needle of the transition indicator moves into the overload zone, when operating in conjunction with a steam locomotive helper, the throttle MUST be reduced. This decreases the horsepower output of the Diesel engine, which in turn will bring the train speed down to the most efficient working speed of the steam locomotive helper. The Diesel locomotive will still pull its rated tonnage at this lower speed, instead of trying to pull excessive tonnage at less than its rated minimum speed, which is faster than that at which the steam locomotive will pull its maximum tonnage.

It should be thoroughly understood that the short time rating zones on the indicator dial are there for the express purpose of protecting the locomotive and as a guide to the engineman for proper locomotive operation. This does not, by any means, set the maximum tonnage rating of the locomotive, since factors to be found on each individual section of railroad will influence the final rating. In such instances Electro-Motive personnel will be glad to make specific tests and furnish the maximum tonnage rating for each division of a railroad, upon request.

The constant reference to the transition indicator pointer in all steps of transition, especially when operating in the short time rating zone, or when in manual transition position, should bring out the importance of this instrument for proper locomotive operation. It is very important that this instrument be maintained to a very high degree of accuracy by the maintenance forces.

Unfortunately the transition indicator only shows operating conditions as reflected by the lead unit, because it has no connection whatever with any of the trailing units. If the engine in the lead unit is off the line, the transition indicator will be inoperative, but automatic transition will occur as usual in the trailing units. When operating in manual transition position, the engineman has but one alternative and in this case it is permissible to use the speed recorder as a guide to shifting transition, Article 206, page 205.

There will be times when the transition indicator and the speed recorder will not always agree exactly, at the time of transition. This should cause no alarm, unless the discrepancy is too great, as climatic and rail conditions sometimes affect train speed. Also, the speed recorder is not always correct, due primarily to wheel wear.

There will also be times when the indicator pointer will not be exactly on the shift line when automatic transition takes place. This is generally the result of varying engine horsepower output caused by different grades of fuel, climatic conditions or altitude. If it is noticed that transition consistently takes place at a considerable time before or after the needle reaches the shift mark, or not at all, it is apparent that some part of the automatic electrical relay equipment is not functioning properly. Since the engineman is expected to exercise good judgement under such conditions, it would be advisable to revert to manual transition by breaking the seals on the transition cutout switches and going over to manual position.

It is mandatory that the locomotive be standing still when the transition cutout switches are turned from automatic to manual, thereafter starting the train in full manual operation. All transition cutout switches in a multi-unit locomotive MUST be turned to the same position. Never attempt to operate with some cutout switches in automatic position and some in manual. This change in operation should always be reported on the work report and the locomotive log book. If the point of relief for the engineman making this change in operation is other than a maintenance point or terminal, the relieving engineman should be advised verbally of this change in operation.

For the information of enginemen, EMD road locomotives are wired so the wheel slip light will flash when automatic transition occurs, from 2 to 3 and 3 to 2. In this manner, the engineman may ascertain if the trailing units are following through the transition sequence. It is normal that no light flashes occur in the motor shunting transitions, 1 to 2 and 3 to 4 forward, and 4 to 3 and 2 to 1 backward. Transition does not occur simultaneously on all units, due to slight inequalities of relay setting, etc., although two units may transfer so close together that the light flashes will run together in one long flash.

MISCELLANEOUS OPERATING INSTRUCTIONS

157. Operation over Railroad Crossings

When crossing railroad crossings reduce throttle to the No. 3 position, in order to minimize breaking of traction motor brushes.

158. Precautions During Locomotive Operation

1. The gauges and indicators listed under Article 148, item B3 should be observed at intervals to ascertain that the locomotive is functioning properly.
2. Check steam generator if in use (See Section 10).
3. Drain air system (see Art. 803).

4. In the event of any Signal Alarm or light, the condition should be remedied at once or the necessary equipment shut down.

159. Changing Operating Ends

When the consist of the locomotive includes two "A" units, the following procedure should be followed in changing from one operating end to the opposite end:

1. REMOVE REVERSE LEVER.
2. With safety control pedal depressed, release independent air brake by placing independent brake valve handle in "Release" position.
3. Make full service automatic brake reduction.
4. Close brake valve cutout cock and release safety control pedal.
5. Move the Rotair valve to the proper "LAP" position.
6. Move the automatic brake valve handle to "RUNNING" position and remove the handle from the brake valve.
7. Remove the independent brake valve handle in "RELEASE" position.
8. Open all switches in control push-button box and close the switch lock.
9. Proceed to cab at opposite end. Check "PC" switch and reset if necessary. Open switch lock on control push-button switch box, close control and fuel pump switches and such other switches as are necessary.
10. Insert reverse lever, automatic brake valve handle and independent air brake handle.
11. Move the Rotair valve to the proper operating position.
12. Move independent brake valve handle to "FULL APPLICATION" position and open the brake valve cutout cock slowly, pausing from 5 to 10 seconds in mid-position.

13. When ready to move locomotive, depress safety control pedal or automatic brake valve handle and move independent brake valve handle to "RELEASE" position.

160. Operating a "B" Unit with Hostler's Controls

Operation at the Hostler's station is the same as an "A" unit. The push-button switches are beside the controller. The brake valve cutout cock is below the brake valve. The bell valve is a globe valve near the controller. Only No. 1 transition is available. Movement of the reverse lever automatically places the locomotive in No. 1 transition. It is to be remembered that the operation of the "B" unit controls will operate all units joined to it.

When securing the hostler's controls be sure all push buttons are pulled out, the controller and reverser pinned, and the brake valve cut out, as these items will affect operation at any other station or cab.

161. Leaving Locomotive (See Art. 210)

Whenever the engineman's station is to be left unattended the locomotive should be secured as outlined in Art. 159, steps "1" to "8" as for "changing operating ends." However, if engines are to be left running the fuel pump and control push buttons must be left in. If engines are stopped be sure hand brakes are set or wheels blocked.

162. Air Box Drains

Each engine has two air box drain tanks incorporated in the engine oil pan near the generator end, one on each side. These tanks have a valve in the drain line so that the tanks may be drained when the locomotive is standing still and sludge and oil from the tank will not be carried onto the running gear. In the event that the drain tank becomes filled, a telltale hole in the tank will blow the overflowing sludge and water into the engine room. If water appears at the telltale hole the cause should be investigated.

163. Unusual Operating Conditions

Such as overloading, running through water, failure of load indicating meter, isolating units, etc. are covered in Section 2.

164. Modified Maximum Field Starting

The F3 locomotive is designed to give exceptionally smooth starting. This is accomplished by timing the load regulator so that the throttle may be opened quickly to the desired position. However, instead of the power building up immediately to the amount indicated by the throttle, it rises slowly, governed by the movement of the load regulator. This steady, slow build-up of power gives exceptionally smooth starting. Usually 20 to 30 seconds elapse between the time the throttle is opened and the train begins to move. While this is desirable in freight service — and is especially beneficial in starting very heavy trains with three or four unit locomotives — it is too slow for passenger service.

To provide a minimum delay in starting passenger trains and yet retain the benefits of slow load regulator timing the "Modified Maximum Field Start" is used. With this, the former 20 to 30 seconds start time is reduced to 8 to 15 seconds, depending upon conditions. A more rapid build-up of power is achieved at lower throttle positions while the speed of movement of the load regulator arm is unchanged at higher throttle positions.

The only difference in the F3 locomotive set for Modified Maximum Field Start and one set for Minimum Field Start is in the adjustment of the load regulator pilot valve.

With Minimum Field starting the load regulator rests in minimum field when the engine is at idle. With

Maximum Field starting it rests at maximum field position. With Modified Maximum Field starting it would rest at maximum field except that the overriding solenoid in the pilot valve causes the load regulator to move toward minimum field whenever the battery field contactor is open. Therefore, with Modified Maximum Field starting the load regulator is in minimum field when the engine is at idle.

When the throttle is opened to Run 1, with Modified Maximum Field starting, the load regulator immediately starts to move toward maximum field, building up the power output of the locomotive. This is in contrast with the minimum field start in which it is necessary to open the throttle to Run 3 to overcome the unbalance setting of the pilot valve toward minimum field. This one factor alone would decrease the time of train starting.

In addition, should the throttle be opened to Run 3, with Modified Maximum Field starting, the movement of the load regulator toward maximum field will be faster than with minimum field setting (no change in needle valve timing on the load regulator). This is due to the fact that with the minimum field setting the movement of the throttle to Run 3 barely overcomes the .040" pilot valve unbalance toward minimum field and barely opens the pilot valve port toward maximum field. The rate of movement of the load regulator is restricted by the small amount of port opening in the pilot valve so that it moves very slowly toward maximum field. On the other hand, in Modified Maximum Field setting the pilot valve at idle already has a .040" port opening toward maximum field to which we add an additional unbalance by opening the throttle to Run 3. This gives a large amount of pilot valve port opening and permits a maximum rate of movement of the load regulator, restricted only by the needle valve setting and not the port opening of the pilot valve so that the load regulator moves as rapidly as possible (established by needle valve settings) toward maximum field.

Above Run 4 the effect of the pilot valve unbalance setting toward minimum or maximum field is negligible in either case and the movement of the load regulator will be the same for minimum field or maximum field settings.

Throttle handling instructions for passenger trains is the same for Modified Maximum Field starting as for Minimum Field starting.

SECTION 2

SPECIAL CONDITIONS AND PROBLEMS DURING OPERATION

200. There are several conditions which may be encountered from time to time which require special operating instructions. If the instructions are closely followed no damage to the equipment will result. Careless operation under these specialized conditions can be very costly.

201. Running in the "Red" – Overload Operation

When starting a train, the pointer will usually move temporarily into the "short time overload" section of the load and transition indicating meter. This represents a normal condition if the pointer returns to the No. 1 green area as the train speed increases. If the pointer remains in the overload area or enters this section of the meter on a grade with the transition lever in No. 1 position, the locomotive is overloaded.

The locomotive is designed to stand overload operation if this condition does not exceed certain limits. The greater the overload, the less time (or mileage), the locomotive can operate safely. The short time overload section of the meter is laid out to cover this principle. The greater the overload, the further the pointer swings into the overload area. The reading of the pointer indicates the number of miles at which it is safe to operate the locomotive at that particular overload.

If an overload condition is encountered, note the mile post at which the pointer enters the "short time overload" area. Watch the pointer carefully. The reading at its furthermost travel to the right must be taken as the maximum distance which the locomotive can be operated while overloaded. Under these circumstances, it is quite probable that the travel of the pointer will not bring it exactly on one of the numbered lines. The reading must then be estimated by the position of the pointer with respect to the adjacent lines. If the maximum pointer movement is in the section between green area No. 1 and line 8, consider 8 miles as the maximum distance.

202. Example - The pointer enters the overload area at, say, mileage 231. At mile post 232, the pointer is slightly to the left of "line 8." If the pointer moves no further, the locomotive can be operated as far as 239 (231 plus 8), under this overload condition. However, the pointer continues to move to the right. At mile post 233, the pointer has steadied out halfway between "line 8" and "line 4." The estimated reading is then "6." This means that the locomotive can be operated under the existing overload only six miles from mileage 231, or to 237. If, by his familiarity with the road, the engineer knows that the grade eases off short of milepost 237, it is safe to continue the overload operation. On the other hand, if he knows the grade continues considerably beyond milepost 237 the permissible overload operation conditions will be exceeded and tonnage must be reduced or the hill "doubled." However, these actions may be taken at any convenient point short of milepost 237. NOTE: ON ANY GRADE OR SERIES OF GRADES: IT SHOULD BE UNDERSTOOD THAT THE OVERLOAD RATINGS ARE NOT TO BE INTERPRETED AS BEING CONSECUTIVE RATINGS; THAT IS: THE LOCOMOTIVE MUST NOT UNDER ANY CIRCUMSTANCES BE OPERATED AT THE ONE-MILE RATING FOR ONE MILE: THEN THE TWO-MILE RATING FOR TWO MILES: THEN THE FOUR-MILE RATING FOR FOUR MILES, ETC. IF THE TRANSITION METER POINTER EXCEEDS THE SHORT TIME RATINGS AS INDICATED ON THE METER, THEN THE

TONNAGE MUST BE REDUCED.

203. **Operating with Steam Locomotive as Helper**

In moving large tonnage trains over heavy grades ordinarily encountered in mountainous territories, steam locomotives are generally used for helper service. In such a movement, it must be known that the steam locomotive can and will pull, as its share of the load, the tonnage of the train which is in excess of the maximum continuous tonnage rating of the Diesel locomotive for the grade over which the train is moved. The steam locomotive must be capable of pulling its share of the tonnage without danger of slipping.

Steam locomotives used as helpers often have tonnage ratings based on speeds lower then the continuous rated speed of the Diesel locomotive. Above such speeds, the Diesel locomotive will absorb more than its proportionate share of the load since its tonnage rating is based on a higher speed. As a result, the Diesel locomotive may become overloaded in endeavoring to gain the minimum speed for its continuous rating. This will be indicated by the transition indicating meter pointer moving to the right of the No. 1 green area into the overload area.

Under these conditions, reduce the Diesel locomotive throttle, allowing the train speed to drop and the steam locomotive to pick up its proper share of the tonnage. As the speed decreases, the transition indicating meter pointer will move to the right. In this event reduce the throttle until the pointer reaches the No. 1 green area. When the pointer remains in the green area the steam locomotive will have assumed enough tonnage to remove the overload from the Diesel locomotive. Operation should be continued at this throttle position.

204. Should the transition meter be out of order it will be necessary to handle the throttle by reference to the speed indicator instead of the transition indicating meter. In this case, the table of "Approximate Continuous Speed Ratings" given below should be used. To apply this data in the table, reduce the throttle notch by notch. After each throttle reduction, allow the train speed to become steady and read the speed indicator. Compare the reading with the figure in the table opposite the throttle position being used and in the column corresponding to the gear ratio of the locomotive. If the train speed is lower than the table figure, reduce the throttle another notch and repeat the procedure, comparing the speed with the line in the table for the new throttle position. Continue the throttle reduction until the train speed becomes equal to or higher than the table speed reading. Continue operation at this throttle position.

Approximate Continuous Speed Ratings
Miles per hour with 40" wheels

Throttle	65/12	62/15	61/16	60/17	59/18	58/19	57/20	56/21
8	12.0	15.5	17.0	18.5	19.5	21.0	22.5	24.5
7	9.5	12.0	13.0	14.0	15.0	16.0	17.5	18.0
6	7.5	9.5	11.0	11.5	12.0	13.0	14.0	14.5
5	6.0	7.0	7.5	8.0	9.0	10.0	10.5	11.0

An example of the use of the table is given below:

Assume the locomotive is one with 62/15 gear ratio. When operating in transition No. 1 and throttle Run 8, with a helper locomotive, the train speed drops to 11.0 MPH. This is under the 15.5 MPH shown in the table for a 62/15 gear ratio locomotive in throttle Run 8. The locomotive is overloaded and if the transition indicating meter were working, the pointer would be to the right of No. 1 green area (700 amperes). The throttle is then reduced to Run 7. The speed drops to 10 MPH and the

helper locomotive assumes more load. The locomotive is still overloaded since the table shows 12.0 MPH for Run 7. The throttle is next moved to Run 6. The speed becomes steady at 9.5 MPH. This checks with the Continuous Speed Rating in the table and operation should be continued with the throttle in this position.

205. **Towing Locomotive**

1. Be sure reverse lever is in neutral position. If the locomotive is to be towed in a train any appreciable distance, the reverser drum must be placed in neutral position manually and should be locked in that position. During normal operation, a locking pin is screwed into the left-hand side of the reverser. To lock the reverser drum in neutral, this pin should be removed and inserted in the hole on the opposite side. Turn the drum to its neutral position and the pin will engage with the hole in the shaft.
2. All isolation switches must be in "START" position. If it is necessary to keep engines idling for any reason while towing locomotive, the fuel pump and control switches should be left in the closed position.
3. The air brake equipment should be set according to the air brake manufacturer's instruction bulletin which includes the following items: (Refer to Fig. 1-5, Art. 122.)
   a. Close brake valve cut out cocks.
   b. Open conductor's valves and reduce brake pipe pressure to zero. Close conductor's valve.
   c. Release locomotive brakes by manipulation of independent brake valve handle.
   d. Remove automatic and independent brake valve handles.
   e. Place Rotair valve in "PASS" (unless special

conditions require a controlled emergency application of brakes on these units in which case the Rotair valve should be placed in "FRGHT.") — Not "LAP" position.

f. Place dead engine cock on D-24 control valve in "DEAD" position.

g. In "B" units place controlled emergency cut-out cock (Rotair valve) and Dead engine cock in the same position as those on "A" units.

206. **Operating without Transition and Load Indicating Meter**

If at any time the transition meter does not function properly, or the lead unit has been isolated, it will be necessary to make transition by reference to the locomotive speed. The table below shows the approximate speeds at which transition should occur at full throttle.

Approximate Continuous Speed Ratings
Miles per Hour with 40" Wheels

From Pos.	To Pos.	GEAR RATIO							
		65/12	62/15	61/16	60/17	59/18	58/19	57/20	56/21
1	2	15	20	21	23	25	27	28	30
2	3	20	26	28	30	32	35	37	40
3	4	41	53	59	63	67	72	78	83
4	3	41	53	59	63	67	72	78	83
3	2	20	26	28	30	32	35	37	40
2	1	15	20	21	23	25	27	28	30
Max. Per Speed		50	65	71	77	83	89	95	102

Transition should be made in accordance with reading of transition meter and should never be made from speed indicator reading, except when the transition meter fails to function.

207. **Freezing Weather Precautions** (See Art. 308).

In freezing weather, precautions must be taken to see that water in the locomotive does not freeze. Steam admission valves are provided on the following equipment and if not in use steam should be supplied to prevent freezing.

Steam Generator (See Section 10)
a. Heating coil valve.
b. Water suction line valve.
c. Water tank valve.

Engine cooling system
a. Steam admission valve to engine cooling water.
b. Valves for steam supply to cab heaters.
c. See Art. 308 for detail instruction.

Toilet water tank valve.

In freezing weather if heating facilities are not available all water must be drained from locomotive.

1. Engine cooling system and cab heaters (see Art. 306).
2. Steam generator (see Section 10)
3. Steam generator water tanks.
4. Toilet water tanks.
5. Air system (see Art. 803)

208. **Starting Engines**

1. Close all switches in distribution panel.
2. At engineer's station close "control" and "Fuel Pump" switches.
3. Place independent brake in full "application"

position.

4. Set "PC" switch.
5. BE SURE REVERSER LEVER IS REMOVED FROM CONTROL STAND.
6. Check engine lube oil and water levels and oil level in governor and air compressor.
7. If engine has been shut down more than 2 hours, open cylinder test valves, pull layshaft closed and press "START" button on engine control panel. Crank engine over a few revolutions and release. If water was discharged from cylinders investigate, if not, close test valves and proceed.
8. Turn on fuel pump switch and check for fuel flow through sight glass on fuel filter nearest engine (mounted on right front of engine).
9. Check setting of overspeed trip (Pull to set).
10. Check governor oil alarm trip button.
11. Hold layshaft 1/4 open.
12. Press engine start button until engine starts (Not more than 15 seconds).
13. Check oil pressure.
14. Check ground relay.
15. Check starting contactor interlocks.
16. Allow engine to idle until water temperature comes up to green area on gauge before working the engine.
17. Place isolation switch in "Run" position (Down).
18. For Starting troubles (see Art. 1110).

209. **Stopping Engines** (For stopping while under power see Art. 216).

1. Place isolation switch in "Start" position.
2. Push engine "Stop" button in and hold it until engine stops.
3. Place fuel pump switch in "OFF" position.
4. Open cylinder test valves on engine (if more

than 2 hour layover).

5. Supply steam to cooling system in freezing weather.

210. Securing Locomotive at Engineer's Control Station In Preparation for Layover

1. Place transition lever in "off" position.
2. Place reverse lever in "neutral" position and remove lever from controller.
3. Open all switches in push button control box and distribution panel (after engines have been stopped).
4. Release air brakes and set hand brake. As an added precaution against locomotive moving, block the wheels. See Art. 158, steps 2 to 8.

211. Tonnage and Speed Ratings

The tonnage ratings of any F3 locomotive depends on the number of units, the grade and gear ratio between the pinion on each traction motor and the axle gear with which it meshes. The table below lists the tonnages for the various horsepower ratings and gear ratios. This table also shows the approximate speeds which the locomotive will develop when hauling its rated tonnage. The maximum permissible operating speed of the locomotive for each gear ratio is also given. This represents the road speed at which the traction motors will turn at the maximum safe RPM.

These minimum speeds listed below MUST NOT be used for rating the tonnage, but only as a guide to approximate the running speed with rated tonnage.

With the listed tonnage ratings, all engines must be up to full rated output. If an engine is low in power, or an engine is "off the line," the tonnage should be adjusted in proportion to the decreased power.

CONTINUOUS TONNAGE RATING FIGURES FOR F3 LOCOMOTIVE

GEAR RATIO

HP	GRADE	65/12	62/15	61/16	60/17	59/18	58/19	57/20	56/21
6000	1.0%	6450	4780	4370	3960	3700	3370	3110	2880
6000	1.5%	4470	3280	3000	2700	2520	2280	2100	1920
6000	2.0%	3360	2460	2230	2000	1870	1680	1540	1440
4500	1.0%	4840	3580	3280	2970	2770	2530	2330	2160
4500	1.5%	3350	2460	2250	2020	1890	1710	1570	1440
4500	2.0%	2520	1840	1670	1500	1400	1260	1150	1080
3000	1.0%	3220	2390	2180	1980	1850	1680	1550	1440
3000	1.5%	2230	1640	1500	1350	1260	1140	1050	960
3000	2.0%	1680	1230	1110	1000	930	840	770	720
1500	1.0%	1610	1190	1090	990	920	840	780	720
1500	1.5%	1120	820	750	670	630	570	520	480
1500	2.0%	840	610	560	500	470	420	380	360
Approx. Min. Speeds at Above Ratings		12.0	15.5	17.0	18.5	19.5	21.0	22.5	24.5
Max. Per. Speed		50	65	71	77	83	89	95	102

In order to avoid overloading the electrical equipment, it is important that the tonnage of the train be kept within the maximum tonnage rating limits of the locomotive except where SPECIAL TONNAGE RATINGS have been supplied to the railroad by the Engineering Department of Electro-Motive Division

PROBLEMS DURING OPERATION

212. If the Alarm Bells Ring

An alarm signal light will be lighted in the unit affected:

RED Engine water temperature over 208° at outlet - (approximately 200° on temperature gauge).

Check water level, shutters, and fans. If condition cannot be corrected at once isolate engine and investigate for cause.

a. AC contactor panel is mounted on the main hatch. Push in both buttons firmly to be sure they are not tripped. (See Art. 630, Item 4).

b. Air supply shut off valve for shutters is mounted on left wall of carbody opposite engine blower.

YELLOW & BLUE Low lube oil pressure or high lube oil suction. Engine will be stopped. Isolate engine and reset governor trip button to stop alarm bells. Check oil level and condition. If no difficulty is evident start engine, check oil pressure. Place engine on line. Watch oil pressure and suction gauge. Under extremely high temperatures an otherwise normal engine may have oil pressure fall low enough to trip the alarm.

BLUE Alternator failure (whenever engine stops while "on the line" this light will light, since stopping engine, of course, stops the alternator). Start engine (check overspeed trip and fuel flow) and attempt to put engine "on the line." If light comes on instantly then check auxiliary generator field fuse and alternator field fuse. If light does not come on, check ground relay (See Art. 224).

GREEN Steam Generator Failure (See Section 10).

NOTE: The yellow lube oil alarm light will burn whenever the Governor low oil alarm switch is tripped whether isolation switch is in "Start" or "Run" position.

The "Low Oil" alarm light and the "alternator Failure" lights are energized through the fuel pump control circuit so that if the "PC" switch is tripped or the fuel pump switch in the cab pulled out or the fuel pump fuse in the operating unit is blown these alarms will not operate.

213. If Locomotive Fails (All Units) to Produce Power with Engines Running

If engines are stopped, start engine or see Art. 1110.

1. Check "Control," "Generator Field," and "Fuel Pump" switches and reverse lever.
2. Check "PC" switch (telltale pin should be down or indicating light not burning).
3. Check control fuses. (Move throttle to "STOP" position, if engines begin to die, quickly return throttle to "Idle." If engines do not slow down check the two control fuses in Distribution Panel).
4. Check brakes.
5. If trouble still persists, check each unit.

NOTE: If locomotive is putting out power the output of the "A" unit can be read directly from the load indicating meter. Throttle response can be told by the sound of the engine. Both are important observations.

214. If Any Unit Fails to Produce Power with Engine Running

If engine is stopped check overspeed trip and fuel flow, and low oil pressure trip button on governor, then start engine or see Art. 208.

1. (Refer to Fig. 1-6, Art. 148) and check each item under "Unit failures check," for proper setting and reading.

2. Check battery field fuse on low voltage panel.
3. A careful check of these items will reveal the more common difficulties (75% of the troubles). Unusual difficulties require a careful study of the particular situation. (See section 11).

215. Any piece of mechanical equipment is subject to some difficulties. An arrangement of protective devices is provided on these locomotives to prevent damage in case of a failure or careless operation. OVERLOADING IS ONE EXCEPTION AND IS ENTIRELY THE RESPONSIBILITY OF THE ENGINEER.

In cases of serious difficulty in a unit the engine should be immediately isolated and an investigation made.

216. Isolating and Stopping an Engine while Under Power or Using Dynamic Brake

(For normal stopping procedure see Art. 209).

If it becomes necessary to take engine "off the line" while the locomotive is operating under power, it should be done as follows:

1. Pull manual control lever shut. Hold until engine stops.
2. When bell starts ringing place the isolation switch in the "START" position.
3. Place fuel pump switch in "OFF" position.

217. Starting and Placing Engine on the Line while Locomotive Is Under Power

1. Start engine in the usual way. (See Art. 208).
2. After lubricating oil pressure builds up, place isolation switch in "RUN" position. If throttle is above 3rd position, hold off on governor to

injector linkage with layshaft manual control lever, to allow engine to come up to speed gradually. Do not place an engine "on the line" when using dynamic brake.

SPECIFIC DIFFICULTIES

218. Recovery of Control of Brake after Penalty Application

1. Place brake valve in "LAP."
2. Close throttle to idle.
3. Place foot on deadman pedal.
*4. Wait until application pipe builds up to main reservoir pressure (listen for exhaust or watch PC switch light - if used).
5. Reset train control.
6. Check PC switch (reset manual PC switch).
7. Release brakes.

*After an Emergency Application, brake valve must be moved to Run before PC switch will reset.

219. Setting "PC" Switch

Recover brake and set manual "PC" switch as above (Art. 218). If "PC" switch is tripped locomotive will have power in No. 1 throttle position (shown on Load indicating meter) but engine speed will not advance as throttle is opened. Fuel pumps will be stopped. In No. 5 or No. 6 throttle position the engines will stop. No bells will ring. The "Fuel Pump" switch in the cab and the fuel pump fuse in the distribution panel will cause the same difficulty as a tripped "PC" switch.

Should the automatic PC switch fail to reset, a pin on the right side of the switch may be pressed.

220. Auxiliary Generator Charging Rate

Failure of auxiliary generator will stop excitation of alternator and cause a Blue light. Normal output should keep battery ammeter at 0 or some charge. Auxiliary generator ammeter can show 20-30 amperes charge and still have 150 ampere output fuse blown. In case of auxiliary generator failure stop engine in that unit and check 30 ampere field fuse and 150 ampere output fuse.

221. Starting Contactors (See Art. 617, 752)

Main contact points must not stick closed. The interlock located underneath main contactor must be closed and making good contact. If interlocks do not close or make contact engine will speed up when throttle is opened but will not load. Above No. 5 throttle the engine speed and fuel indicators on the governor will be unbalanced to minimum fuel (low power piston) and load regulator will point toward 5 o'clock.

222. Control Air (See Art. 804)

Control air must be 80 ± 3 pounds to supply air to close main contactors. Failure of control air will stop power output as main contactor will not close. Engines will speed up in response to throttle. Above No. 5 throttle, the engine speed and fuel indicators will be unbalanced to minimum fuel (low power piston) and load regulator will point toward 5 o'clock.

223. Battery Ammeter

Battery ammeter should always show 0 or some charge. Immediately after starting engine it will show 30-40 ampere charge. If discharge is indicated check auxiliary generator output. If trouble cannot be remedied anticipate failure as battery runs down.

224. **Ground Relay** (See Arts. 637, 732)

Pointer points to yellow dot when set, red dot when relay is tripped. When the Ground Relay is tripped the engine will not speed up when throttle is opened. In No. 5 or No. 6 throttle position engine will stop and blue light will light. To reset, isolate engine, reset relay, and put engine on line. If relay continues to trip isolate unit.

225. **Engine Speed and Fuel Indicators** - On Governor

There are two pointers on the cover of the governor. One of these pointers indicates the throttle position of the engine and is labelled "Speed." The second pointer indicates the position of the power piston in 16ths of an inch and is labelled "Fuel." The lower the number on the "fuel" scale the greater the quantity of fuel which is being injected into the cylinders. In No. 8 throttle ("Speed") position the fuel indicator needle should read between 5 and 6 if the engine is properly loaded. In general the two pointers should be checked only in No. 8 throttle position as indications at part throttle may be misleading. If a marked variation is noted the trouble should be investigated. Excessive fuel (lower number on fuel scale) will indicate engine trouble. Minimum fuel will indicate electrical trouble.

226. **Isolation Switch** (See Art. 735).

Isolation switch must be firmly in "run" (downward) position to obtain power from the unit. The switch should be opened and closed only with engine at idle speed (or stopped when in dynamic braking). Use the manual layshaft lever to bring engine to idle speed or to stop engine when the locomotive is under power or in dynamic braking.

227. **Load Regulator** (See Arts. 142, 627, and 738).

When operating in No. 8 throttle the load regulators throughout the locomotive should be in approximately the same position. Extreme unbalance of the load regulator arm in one unit to maximum or minimum field is an indication of difficulty and should be investigated.

If during full throttle operation one unit shows minimum field (arm in 5 o'clock position) trouble may be either mechanical or electrical. If in maximum field (arm in 8 o'clock position) inspect for loss of electrical load.

228. **Fuel Flow** (See Art. 510).

For proper engine operation a good flow of fuel should be indicated in the fuel return sight glass located on the duplex filter assembly nearest the engine. No fuel should flow through the 45 pound glass next to it. Fuel flow through the 45 pound glass indicates clogged duplex filters and if great enough to stop flow through the fuel return sight glass engine may lose power.

If no fuel is flowing through the fuel return sight glass check fuel pump motors and fuel pump. If pumps in all units are stopped check "PC" switch, fuel pump switch, and fuel pump fuse in distribution panel. (Do not confuse fuel pump fuse and fuel pump motor fuse).

If pumps in other units are running, check switch on engine control panel and control switch, 80 ampere control fuse and fuel pump motor fuse in the distribution panel of unit affected. If pump is running but no fuel is pumped check fuel supply, emergency fuel cutoff under the unit (See Art. 505), or check for a suction leak in piping between tank and pump.

229. **Overspeed Trip** (See Art. 506)

When tripped, fuel is stopped at the injectors and engine cannot be started. Whenever an engine is found stopped always check overspeed trip by pulling firmly on the lever to be sure it is set.

230. **Battery Field Fuse**

There is an 80 ampere fuse in the battery field circuit of each main generator. Should this fuse be blown no power will be developed in the unit affected. The battery field fuse is located on the low voltage panel which is in the electrical control cabinet and is accessible through a door at the rear of the cab.

231. **Running through Water**

Under ABSOLUTELY no circumstances should the locomotive pass through water which is deep enough to touch the bottom of the traction motor frames. When passing through water, always go at a very slow speed (2 to 3 miles per hour). Water any deeper than 3 inches above the top of the rails is likely to cause damage to the traction motors.

232. **Operation of F3 with FT or F2 Units**

In many instances it may be desirable to operate combinations of FT, F2 and F3 units in a locomotive. This is an acceptable practice provided gear ratios are the same, and will be entirely successful if the instructions below are followed. No change in operating technique is necessary except for the conditions listed.

1. Manual transition must be used.
2. Throttle must be reduced to No. 6 position for 2 to 3 or 3 to 2 transition.
3. Starting trains should be done according to instructions for FT units if in locomotive consist.

Locomotives with different gear ratios may be operated together only if a study is first made by Electro-Motive, and special instructions issued.

When using dynamic brakes all units must be so equipped. If the operating cab is equipped for operation of dynamic brakes when locomotive is in reverse (all F3, F2 and some FT) this feature may be used. It will permit use of dynamic braking in reverse on all units.

NOTES

SECTION 3

COOLING SYSTEM

300. Description

The cooling systems of the various engines in the F3 locomotives are independent of each other. They are similar in every respect except that the "A" units have cab heaters.

Four direct motor driven cooling fans are mounted in the main hatch above the engine. The fan motors are electrically connected to the D-14 alternator through four contactors located in the AC Contactor Cabinet, each contactor serving one fan motor. These contactors are operated by the thermostat switch located in the outlet elbow of the right-hand radiator bank. The automatic shutters are operated by two air cylinders located one on each side of the locomotive.

The cooling system is designed so that the water level is below the radiators when the engine is shut down. Freezing of radiators is thereby prevented during cold weather. Operating the system at this level has the following additional advantages:

1. Eliminates expansion overflow and loss of radiator compound during operation. (Amount of expansion is approximately 15 gallons.)
2. Permits visual indication of loss of water by means of the water level gauge glasses.

Distilled water containing an inhibitor should be used in the cooling system to offset the accumulation of scale and foreign matter, which contributes to overheating the engine.

301. **Operation of Cooling Water System**

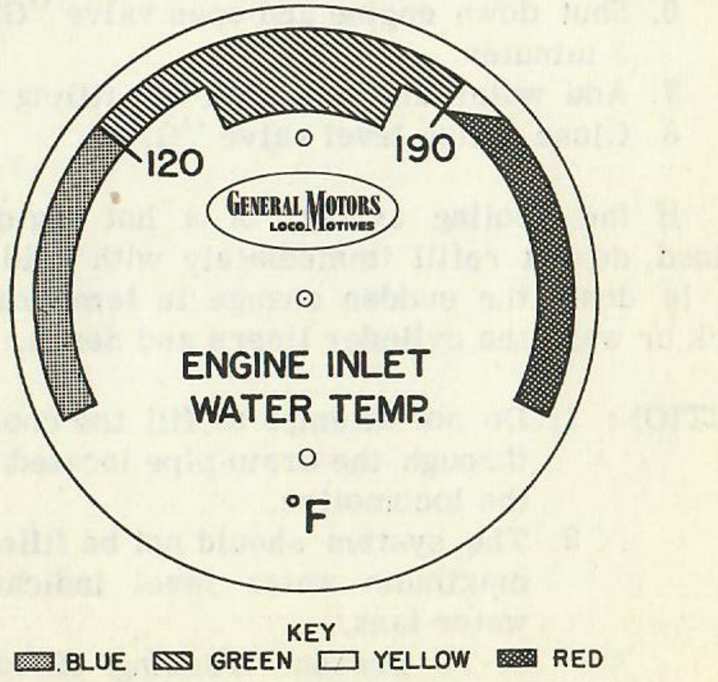
Water is drawn from the oil cooler and water tank assembly by centrifugal water pumps located on the front end of the engine. These pumps circulate the water to the bottom of each cylinder liner, up through the cored passages of the cylinder liner and cylinder head, and out through the outlet manifold. From the engine, the water flows to two banks of radiator sections located in the main hatch over the engine. Here the water is cooled, returning through the oil cooler assembly to the engine. See Chart V in the Appendix of the manual for description of the oil cooler and water tank assembly.

The radiators are cooled by four A.C. motor driven fans which receive their current from the alternator which is built into the main generator. The automatic temperature control is arranged so that the fan motors do not operate until after the shutters are opened at approximately 166° F. The fan motors are then automatically started consecutively at 169° F. according to cooling demands until all fan motors are operating at 178° F. All fans cut out and the shutters close when the engine water temperature drops to 163° F. The fan speed varies directly with the engine speed and is so proportioned that the fans rotate at 1550 RPM when the engine is turning at 800 RPM. The number of fan motors actually in operation depends upon the cooling demands, due to weather conditions and load imposed on the engine. Operation of the transfer relays (or the new type summer-winter transfer switch) control the sequence in which the fans cut in. (See Art. 641 for Fans and Art. 760 for Transfer Relay.)

In winter weather a switch located along side the AC motor contactors in the AC contactor cabinet may be switched to "Winter" position, this changes fans and shutter sequence to "Winter" setting. The shutters then open when the third fan comes into operation at 175°. (See Art. 630).

A water temperature gauge is located in the suction line to one water pump and indicates the water temperature into the engine. The automatic control is operated from the water "out" temperature, so the temperature indicated on the gauge may be as much as 14° below the above temperatures at full load. This gauge has a color-coded dial with black lines indicating the 120° F. and 190° F. points. Below 120° F. the dial is colored blue, from 120° F. to 190° F. green, from 190° F. 200° F. yellow merging into red, and full red above approximately 200° F. The normal operating range is indicated by a wide area of the green section. Operation outside of this wide green section should be investigated immediately for cause.

The temperature switch (Arts. 630, 755) that controls the automatic shutters is adjusted at the maintenance terminal to open and close at the correct temperatures and should NOT be changed by any unauthorized person.



Water Temperature Gauge - Fig. 3-1

302. Filling the Cooling System

The system is filled either through the filler pipe located on the roof of the locomotive above the water tank, or through the filler pipe at the rear of the unit on either side.

To fill the system proceed as follows:

1. Stop engine.
2. Open filling level valve "G" (Chart V).
3. Fill slowly until water runs out filling level pipe at valve "G."
4. Close filling level valve "G."

If filling a dry or nearly dry engine also follow these additional steps:

5. Start engine and run for several minutes. This will eliminate any air pockets in the system.
6. Shut down engine and open valve "G," and wait 3 minutes.
7. Add water until it runs out filling level pipe.
8. Close filling level valve "G."

If the cooling system of a hot engine has been drained, do not refill immediately with cold water. If this is done, the sudden change in temperature might crack or warp the cylinder liners and heads.

CAUTION: 1. Do not attempt to fill the cooling system through the drain pipe located underneath the locomotive.

2. The system should not be filled above the maximum water level indicated on the water tank.

a. To prevent freezing of radiators in winter.

b. To prevent loss of rust inhibitor when draining back to "G" valve level.

CAUTION: As specially treated water must be used in the cooling system, no water should be added except at an approved watering station. Abnormal use of cooling system water, or absence of corrosion inhibitor, as indicated by lack of color, should be noted in the locomotive log and reported at the first maintenance point.

303. Operating Water Level

There are two 16" water gauge glasses located on the water tank above the engine control and instrument panel. These are so arranged that the glasses overlap and provide full operating water level coverage. The "G" valve is located above and to the rear of the left rear engine room door. The water level should never be above this point with the engine shut down. The drain from this valve passes through a funnel for easy visibility. Water will not run from "G" valve after engine has been properly filled and brought to level.

Operating water levels are stencilled on the water tank next to the water gauge glasses to indicate proper operating levels. Capacity of a "B" unit cooling system is 220 gallons to the maximum level mark and 173 gallons to the minimum level. An "A" unit holds approximately 15 gallons more, due to the inclusion of cab heaters and related piping. The engine should never be operated with the water below the low water level. Progressive lowering of water in the gauge glasses indicates a leak in the cooling system and should be reported.

304. Engine High Temperature Alarm Switch

A thermal sensitive element is installed in the water outlet manifold at the rear of the engine. If water at this point exceeds 208° the switch located on the engine control panel trips and the red light in that unit and the alarm bells throughout the locomotive are energized (See Art. 212). The temperature at the outlet manifold may be considerably higher than the gauge temperature (See Art. 301).

305. Checking Circulation

The water temperature dial gauge located in the water pump inlet elbow may be used as a means of detecting an irregularity in the operation of the cooling system. High water temperatures indicate:

1. Fans not operating.
2. Shutters not operating properly.
3. Insufficient water in cooling system.
4. Faulty circulation.

306. Draining the Cooling System

The engine water drain is located on the center line of the locomotive at the accessory end of the engine. Drainage from this valve spills into a funnel in the floor of the locomotive and is piped to the left side of the underframe, forward of the No. 2 bolster. This drain will empty the water tank, oil cooler, radiators, and all of the engine except the bottom of the right bank water pump scroll. Removal of the bottom pipe plug will drain this scroll. Should it be necessary to drain the cab heaters on "A" unit, see Chart VI. The following steps should be taken:

1. Open cab heater valve (3) located above the steps leading into the cab.
2. Open the cab heater drain valve (9) located behind the No. 2 sand box on the left side of the locomotive. When this valve drains completely then open the cab heater steam valves (2) at each cab heater.
3. Open the steam line drain valve (4) on the right side of the engine room at the foot of the steps leading to the cab.

307. Flushing the Cooling System

Complete instructions for flushing the cooling system are outlined in Maintenance Instruction 1706.

308. Freezing Weather Precautions (See Art. 207).

Do not use any kind of anti-freeze solution in the cooling system. If locomotive is to be left standing where there is danger of freezing, steam may be supplied to the cooling system, or the system can be drained. Should it be desired to steam heat the cooling system when the engine is not running, the following steps should be taken:

1. Open the "G" valve.
2. Open the steam admission valve (Chart V) located at the left front of the engine. On "A" unit (see Chart V), the following additional valves must be opened (Chart VI).
    a. Close the cab heater valve (3) above the left side steps leading into the cab.
    b. Open the steam admission valve (7) at the foot of the right side steps leading into the cab.
    c. Open the steam valves (2) at each heater.
3. Make certain steam trainline valves are open (If external source of steam is used).

NOTE: Check amount of inhibitor in water after using steam for heating purposes. Add necessary inhibitor to replace loss or report to maintenance point for attention.

309. **Cab Temperature Control** (See Art. 133)

The cab heaters operate on hot water from the engine cooling system and are equipped with a motor driven fan for maximum radiation. Valve (3) on Chart VI must be kept wide open in freezing weather.

SECTION 4

LUBRICATING OIL SYSTEM

400. **Description**

The lubricating oil systems of the various engines throughout the locomotive are identical to and independent of each other. The oil is stored in the oil pan of the engine, instead of an oil supply tank, which classifies the engine as a wet sump type.

The engine lubricating oil system is a pressure system using two positive displacement gear type pumps combined in a single unit. One pump delivers oil for the pressure lubricating system, the other for piston cooling. The oil supply to these pumps is drawn from the oil strainer chamber through a common suction pipe.

A scavenging oil pump is used to draw oil from the engine oil pan through a strainer, pump it through the lube oil filter to the cooler core section of the oil cooler tank and return it to the strainer chamber. See Chart V.

401. **Operation**

When the engine is started, the pressure pumps pick up oil from the bottom of the strainer chamber. This oil provides an initial supply for lubricating the engines until the scavenging pump has refilled the strainer chamber. Until the scavenging oil reaches the strainer chamber, the pressure may read low on the engine control and instrument panel gauge.

A baffle plate or "dam" tends to maintain the oil level in the cooler core chamber. This oil level will vary depending on engine speed. Oil flowing over this dam returns to the strainer chamber and then overflows into the engine oil pan, keeping the scavenging pump suction pipe under oil. If the oil is too cold and heavy or if the Michiana filters are dirty, the relief valves located in the filter housing will open to by-pass the oil past the filters. If the oil is too cold or heavy or if the cooler core is dirty, the oil will flow over the cooler core into the strainer chamber to keep the pressure pumps supplied.

With the engine running the oil level should always be between the "LOW" and "FULL" marks on the bayonet gauge in the engine oil pan. The oil level can be checked with the engine running at any speed.

402. Adding Oil to System

When oil is added to the system, it must be poured through the opening having the square cap on top of the strainer housing. Should the round caps be removed while the engine is running, hot oil under pressure will come from the openings and possibly cause personal injury. When the engine is stopped, oil added through one of the round openings will not be properly filtered before entering the oil pan. Therefore, never attempt to add oil through either of the round openings, whether the engine is running or stopped. See Chart V in Appendix.

When the engine is stopped, all the oil in the cooler core chamber will drain into the strainer chamber and then overflow into the engine oil pan, which will bring the engine oil pan bayonet gauge reading to "system charged." This level is below the "system uncharged" level because some oil is trapped in the lube oil filter, oil lines and engine.

403. Main Bearing Lubricating Oil Pressure

Lubricating oil pressure must be maintained at all times. When starting a cold engine, allow it to idle for some time and see that pressure starts to build up almost immediately. The pressure should rise on a cold engine to about 50 pounds and will run approximately 35 to 45 pounds at 800 RPM with engine warm. At idle, pressure should be at least 6 pounds.

With normal operation, the lubricating oil pressure should not drop below 20 pounds, with engine running at 800 RPM.

However, if the water temperature cannot be held below 180° F., it will be permissible to operate the engine with lubricating oil pressure, at the rear end of engine, as low as 15 pounds.

This low limit on pressure can only be permitted when the oil temperature is high as a result of the water temperature being above 180° F.

If lubricating oil pressure drops below 14 to 16 pounds the low lube oil pressure protective device will shut the engine down.

404. Low Oil Pressure (See Art. 139).

If the lubricating oil pressure, in the engine blower line, falls below 14 to 16 pounds at 800 RPM or 4 to 5 pounds idling speed, the governor will stop the engine. The governor reset button will be "out" and the yellow "Low Oil" alarm lights will light.

When the engine is started and allowed to idle, the governor will again shut down the engine after a 40 second delay if the low oil pressure condition is still present. This time delay permits observation of gauges to determine the cause of the trouble. At 800 RPM the time delay is only 1 to 2 seconds.

4

If the Low Oil alarm trip switch has been tripped the yellow light will be lit and the alarm bells will ring even though the engine is isolated. To stop bells and light, the governor trip button must be reset and the isolation switch placed in the "START" position.

Low oil pressure and high oil suction protection is afforded at any time the engine is running. The position of the isolation switch, control circuits, fuses, etc. have no effect on the low oil pressure shutdown mechanism since it is hydraulically and not electrically actuated.

405. Lube Oil Suction Gauge

The lube oil suction gauge is mounted on the engine control and instrument panel. It will indicate high pump suction caused by clogged lubricating oil strainers in the strainer chamber. The color-coded dial is marked off in green, yellow and red blocks. Under normal conditions the needle of the gauge should be within the green portion of the dial. If the oil strainers become partially clogged, the needle will advance to the yellow portion of the dial. If the strainers become clogged to the extent that the pump suction reaches the value at which the safety control section of the governor is set to operate, the engine will stop. The needle will be in the red portion of the gauge dial, at the moment the engine is shut down, but will move immediately to the green.

406. Oil Separator

The oil separator is mounted between the engine scavenging air blowers over the main generator. Vapor from the oil pan and gear train housing is drawn through the oil separator to the blower intake. The metal screen in the separator condenses oil from the vapor and returns the oil to the engine oil pan.

POSSIBLE LUBRICATION TROUBLES

407. Absence of Oil in Oil Strainer Chamber

This may be caused by an inoperative scavenging system or an open drain valve. Failure of scavenging system may be due to a broken or loose oil line connection causing an air leak, a faulty scavenging oil pump, or clogged suction strainers.

408. Low Lubricating Oil Pressure

This may be due to the relief valve being stuck open, broken oil lines, clogged strainers, excessive bearing wear, low oil viscosity, faulty pumps, diluted oil, or extremely high engine temperature.

409. Failure of the Oil Pump

This may be due to a sheared shaft, broken housing, or damaged gears. If relief valve sticks open, dirt may be lodged on seat.

410. Dilution

Fuel. It is possible for fuel oil to get into the lubricating oil if an injector is defective, or if a fuel oil line connecting the injector to the fuel oil manifold is loose or broken. If such a condition has existed, the viscosity of the lubricating oil should be checked.

On the road, dilution may be indicated by gradual rise of the engine oil level during operation of the locomotive. The oil pressure will also fall and read lower than normal. When such conditions are noted, they should be reported for investigation at the maintenance point.

Water. Water entering the oil can often be detected by discoloration of the oil to a brown or gray color. Considerable water will cause the oil to thicken. An engine should not be run if the presence of water in the oil is detected.

411. Excessive Oil Consumption

This may be caused by an oil leak, broken or stuck piston rings, worn cylinder liners, damaged blower oil seals, dirty or clogged oil separator screen, improper grade of oil, leaking crab stud seals, or clogged drain holes in pistons under the oil control piston rings. Report difficulty as well as cause of trouble, if determined.

412. Little or No Oil Consumption

This may be due to water or fuel leaking into the oil, or to the use of too heavy an oil. Report difficulty as well as cause of trouble, if determined.

SECTION 5

FUEL OIL SYSTEM

500. Description

The engine in each unit of the locomotive has its own fuel system. The 1200 gallon fuel supply tank is mounted underneath the unit. From the sump of the main tank all fuel for the engine must flow through the emergency fuel cutoff valve into the supply sump and then be pumped to the engine. The supply sump is a separate reservoir, although attached directly to the main fuel supply tank.

When the emergency fuel cutoff valve is open the supply sump may fill permitting the fuel pump to draw fuel. Fuel from the supply sump passes through the suction filter to the pump and is then pumped through the Ful-Flo filter, and the sintered bronze duplex filter to the injectors. Considerably more fuel is pumped to the injectors than is necessary for the operation of the engine. The surplus fuel oil lubricates and cools the internal mechanism of the injectors and then returns to the fuel tank through an orifice and sight glass known as the Fuel Return Sight Glass. See Chart VII in the Appendix. The fuel pump is protected from overload caused by a restriction on the pressure side of the system. Should the Ful-Flo filter become clogged, a fifteen pound differential pressure valve in the by-pass line around the filter will open permitting fuel to by-pass the filter and continue to supply the engine. Should a stoppage occur in the duplex filter or the injector filters which will cause the pressure at the duplex filter to rise to 45 pounds, the relief valve in the 45 pound sight glass mounted on the duplex filter will open by-passing the filter and engine and returning fuel directly to the main supply tank.

Should both the Ful-Flo filter and the duplex filter become clogged, the total pressure at the pump may reach 60 pounds before the 45 pound relief valve opens. If sufficient fuel is by-passed by the relief valve to starve the engine and affect its performance, it should be shut down.

The use of the correct grade of fuel oil is of the utmost importance. Refer to Maintenance Instruction 1606 for fuel oil specifications. For details of injectors refer to the Engine Maintenance Manual.

501. Filling Fuel Tanks

The fuel tanks can be filled from either side of the locomotive. Due to baffles in the tank, the maximum rate is 250 gallons per minute. Watch the fuel level gauge at the filler casting to prevent overflowing the tank. The fuel should be filtered through a reliable fuel filter before it enters the tank. The fuel capacity of each tank is 1200 gallons. Do not handle fuel oil near an open flame.

502. Fuel Level Gauge (When Filling Tank)

A direct reading sight level gauge is located on each side of the fuel tank adjoining the fuel fillers. This gauge indicates level of fuel oil starting at 4-1/2 inches from the top of the tank and should be observed while filling the tank to prevent overflowing.

503. Draining Fuel Tanks

The fuel tank sump has two drain plugs for draining the tank and two special drilled plugs for draining any water which may have settled in the tank sump. By backing the special plugs part way out, water can be drained from the sump. See Chart VII.

Locomotive fuel tank sumps should be drained periodically to prevent excessive accumulation of water.

The drain plug should be removed from the supply sump occasionally for draining sediment. Fuel storage tank sumps should be cleaned periodically.

504. Fuel Tank Vents

Two vents, one on each side, with 4-inch flame arrestors, terminate outside the locomotive unit.

505. Emergency Fuel Cutoff Valve

In the event of fire, an emergency fuel cutoff valve is provided to cut off the fuel supply to the fuel pump. The valve is located in the feed line between the fuel tank sump and the supply sump.

On each side of the locomotive, attached to the side skirt, is a small box with a lift cover. Enclosed in this box is a pull-ring on the end of the cable running to the emergency fuel cutoff valve. A similar ring is located in each cab. The valve can be closed, and the fuel cut off, by pulling any one of these three rings. If closed, the valve underneath the fuel tank must be reset manually to the "open" position by pulling up valve stem and resetting the yoke which holds the valve open. The valve is located inside a compartment with a slide cover.

506. Overspeed Trip (See Art. 229)

This is a flyweight on the engine camshaft which operates small cams under each injector rocker arm to raise the rocker arm cam followers off the camshaft cam, thus preventing injection of fuel. The trip operates at approximately 910 RPM of the engine. The overspeed trip may be caused to operate by sudden loss of electrical load, such as wheel slippage or ground relay tripping.

The overspeed trip resetting lever is located on the front end of the engine directly behind the engine governor. If trip operates, reset by pulling lever in a counter-clockwise direction until it latches.

507. **Fuel Gauge (Remote Reading)**

The fuel gauge is a direct reading, air-operated gauge which indicates the quantity of oil in the fuel tank. The gauge is located in the engine room on the engine control and instrument panel. The needle valve below the gauge must be opened for gauge reading.

508. **Fuel Pump**

The fuel pump assembly consists of an electric motor and a pump of the internal gear type. The gear pump is driven by the motor shaft through a flexible coupling. Do not leave the fuel pump running unnecessarily.

509. **Pump Suction and Ful-Flo Filter**

The fuel oil drawn from the supply sump passes through the suction filter to remove any foreign material that might damage the fuel pump. Fuel leaving the pump is again filtered by the Ful-Flo filter which has a by-pass line with 15 pound differential pressure valve to by pass fuel if the filter is clogged.

510. **Sintered Bronze Fuel Filter Assembly**
(See Art. 228).

This fuel filter consists of two sintered bronze elements, an orifice and sight glass, and a 45-pound relief valve and sight glass. It is mounted on the right front end of the engine.

The fuel being pumped to the engine may pass through either filter element to the fuel manifold on the engine.

As the fuel enters the injector, it is filtered for the fourth time by a small filter mounted in the injector body. The purpose of all this filtering is to protect the finely machined parts of the injector.

As the surplus fuel leaves the injector, it passes through the fuel outlet filter in the injector body which prevents a reverse flow of fuel from carrying dirt into the injector when the engine is shut down.

The fuel oil then passes through the fuel return sight glass (sight glass nearest to engine), returning to the fuel oil tank. The orifice retards the flow of fuel from the injectors so that approximately a 5-pound head is maintained in the fuel return manifold from the injectors. A drop in fuel level in this glass, or an empty glass, will indicate that the engine is not receiving its full supply of fuel. Air entering the fuel line at any point on the suction side of the fuel pump will cause the engine to misfire or stop. Air or gas in the fuel system will appear in this glass in the form of bubbles. The presence of bubbles, with the engine shut down and fuel pump running, indicates an air leak in the suction line. If bubbles appear only when the engine is running, an injector is allowing gas to escape from an engine cylinder into the fuel line.

The 45-pound sight glass will show fuel by-passing when the sintered bronze filters collect enough dirt to build up a back pressure of 45 pounds. Should this occur, the relief valve will open and the fuel will by-pass the filters and engine and return to the fuel tank. No attempt should be made to run the engine until the filters have been cleaned or changed. There is a small amount of normal leakage past the 45-pound valve. This will flow through the small bleed holes in the sight glass stand pipe. If the 45-pound valve is forced open it will be evidenced by the flow of fuel over the top of the stand pipe.

511. Injector

For information on injectors, refer to Engine Maintenance Manual.

512. Fuel Failure

If fuel pump is running but fuel does not show in the fuel return sight glass, check the following:

1. Supply of fuel in the tank.
2. Emergency fuel cutoff valve.
3. Broken motor or pump shaft, or loose flexible coupling.
4. Loose, broken or clogged supply line.
5. 45-pound relief valve stuck open.
6. Defective pump.
7. Check suction filter gasket for air leakage.
8. Dirty suction filter.

If electric motor is not running in one unit, check the following:

1. Fuel pump switch.
2. Main battery switch in unit.
3. Main control knife switch and fuse in unit.
4. Fuel pump motor fuse.
5. Fuel pump contactor in the engine control and instrument panel.
6. Electrical connection at motor.
7. Fuel pump motor brushes.

If no fuel pumps in locomotive will operate see Art. 228.

SECTION 6

ELECTRICAL EQUIPMENT

600. The design characteristics of these locomotives are such that within all practical limits the horsepower delivered to the traction motors is the same at full throttle regardless of locomotive speed or gear ratio. It follows from this that gear ratio has no appreciable effect on the tractive effort of the locomotive.

These statements must be qualified; the high amperages developed with high speed gear ratios at starting prevent full horsepower from being applied during starting. Thus in order to start heavy trains and to use full horsepower for low speed tonnage trains without damage from overheating of electrical equipment a low speed gear ratio is needed. Top speed of the locomotive is limited by the RPM of the traction motor armature so that a high speed gear ratio is required for high speed train operation.

601. There are four main electrical systems in the locomotive. High voltage, low voltage, dynamic braking and alternating current. The first three systems operate on Direct current.

The high voltage system which contains the D-12 generator and the four traction motors provides the power for the locomotive. The low voltage system supplies all control circuits and most of the accessory circuits. The dynamic braking circuit is supplementary to the high voltage circuit and is used to reverse the function of the power circuit to provide a retarding rather than an accelerating effect and is used for braking. The alternating current system provides an advantageous means of driving heavy accessories.

HIGH VOLTAGE SYSTEM

602. When the locomotive is standing with the throttle in "idle" there is no circuit through the main generator and the traction motors, nor is the main generator producing any electricity since the "excitation" or field circuits (battery and shunt) are open.

In order to get power from the locomotive the main Generator-Traction motor circuit must be closed by means of the S14 and S23 contactors, also the main Generator must be made to produce electricity which is done by closing the shunt and battery field contactors.

When the main contactors and the field contactors are closed (by operating controls) some power is produced in the locomotive. The power output is increased by speeding up the Diesel engine. The load regulator controls the amount of "Excitation" of the main generator so that the engine puts out its full share of power for any given throttle position without overloading the engine.

As the locomotive speed increases after starting natural laws of electrical equipment soon tend to make the power output of the traction motors drop off. To defeat this a change in the electrical circuit is made just before the drop off begins. This change in electrical circuit is called transition. The first change from No. 1 position to No. 2 position of the manual transition lever connects by-pass (shunt) circuits around the fields of the traction motors so that more current can pass through the armature to maintain full power output of the locomotive.

As the speed further increases there is again a tendency for power to drop off. This time the transition lever is moved from No. 2 to No. 3 position. A complete change in electrical circuit is made, the field contactors open, dropping the power output of the main generator, the shunt contactors which were closed in No. 2 drop out, the main contactors S14 and S23 drop out as P1, P2, P3, and P4 close changing the traction motors from a series-parallel to a parallel hook up. When the change is complete the field contactors again close, the power output of the main generator is restored and full horsepower is delivered by the locomotive.

At very high speed there is again a tendency for power to drop off and the shunts used in No. 2 are again connected when the manual transition lever is moved to No. 4. This maintains full output from the locomotive to the extreme range of its speed. With decreasing speeds such as are caused by grades a reverse sequence of transition is required to prevent overloading.

Detail of the function of the individual pieces of equipment in the high voltage system and a detailed electrical circuit of both manual and automatic transition may be found elsewhere in this section of the manual.

603 Main Generator

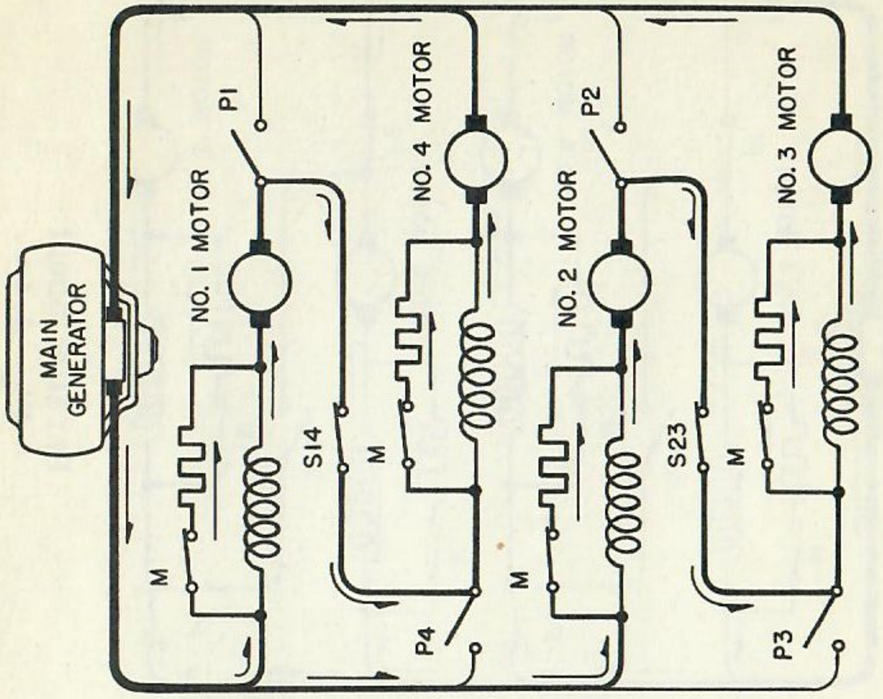
The voltage of the main generator is nominally 600 volts but varies with the speed of the engine and the conditions of operation of the locomotive. The main generator contains six field windings, starting, differential, commutating, compensating, battery, and shunt. The starting field is used only when the main generator is used as a starting motor to turn over the Diesel engine. The differential field is a type of field used almost exclusively on constant kilowatt output generators. It opposes the battery and shunt fields and functions to reduce generator excitation at high generator amperages. The commutating field wound on the generator interpoles is to provide proper commutation. The compensating field is composed of a series of windings embedded in the face of the main poles of the generator. The purpose of the compensating field is to minimize distortion of the field flux set up by the armature current and to provide better commutation. The differential and commutating fields are permanently connected and are a matter of engineering design to provide desired generator characteristics and proper commutation. The shunt field also is designed to obtain the desired generator characteristics but is not permanently connected (See Art. 628). A shunt field contactor interrupts the circuit under conditions described in “TRANSITION SEQUENCE” (Art. 620) later in this section. The battery field is separately excited by low voltage current which is varied by means described under BATTERY FIELD” (Art. 624). Variation of the battery field excitation controls the electrical output of the main generator.

604. Traction Motors

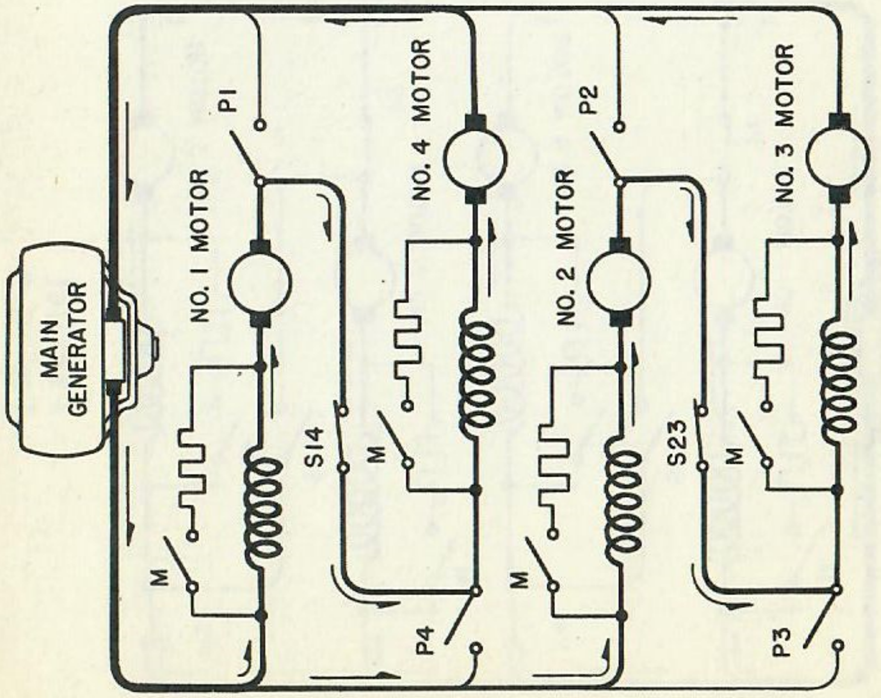
The traction motors are direct current series motors geared to the wheel axles. The motors are reversed by changing the direction of flow in the field windings, the direction of current flow through the armature remaining the same. This is accomplished by a reverser drum in each unit which is operated by electro-pneumatic control from the operating cab. The reverser drum is shown in Fig. 7-4 (Art. 741). (For operation of Reversing Control see Art. 619).

605. Traction Motor Circuit Control

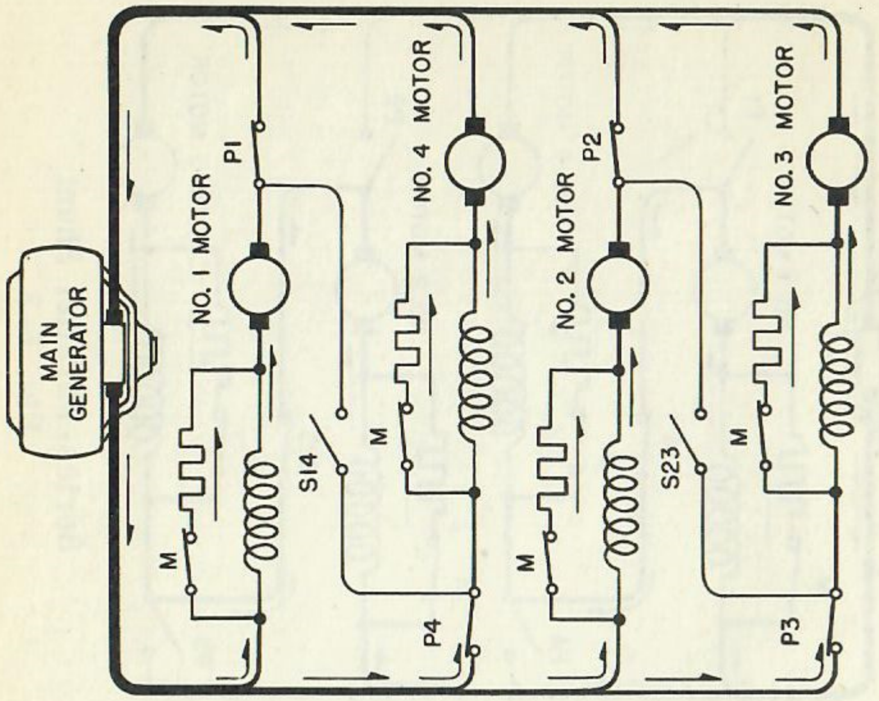
The arrangement of traction motor connections is controlled by the movement of the transition lever in the cab or by automatic action on locomotives equipped with “automatic transition.” In either case, the various connections are set up by the operation of electro-pneumatic power contactors and are designated by letter and number. There are two series (S14 and S23), and four



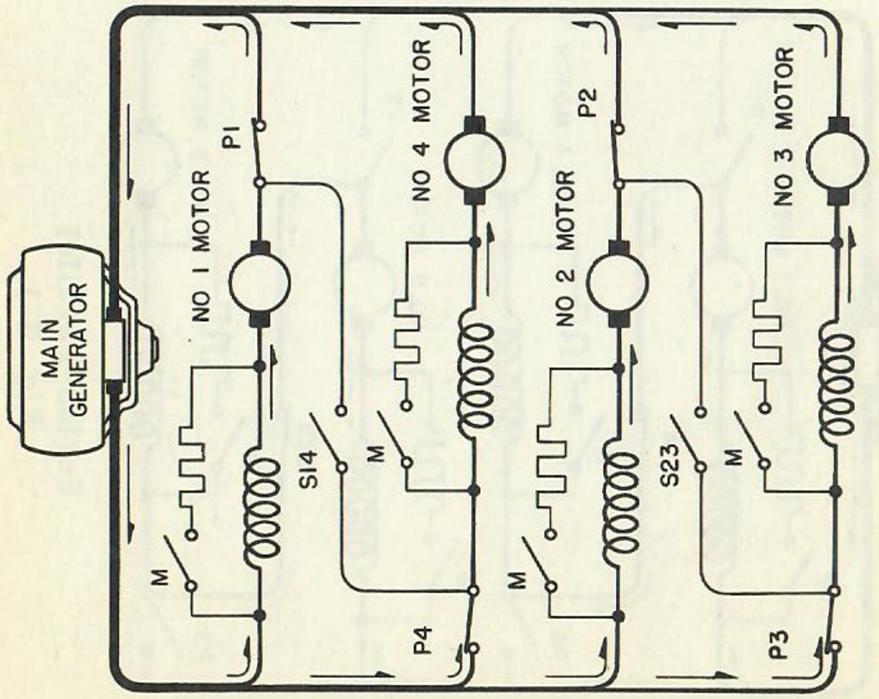
Series-Parallel Shunt
Fig. 6-2



Series-Parallel
Fig. 6-1



Parallel Shunt
Fig. 6-4



Parallel
Fig. 6-3

parallel (P1, P2, P3 and P4) contactors which are operated individually by "magnet valves." A magnet valve is an electrically operated air valve which admits air to the contactor operating cylinder when the winding coil is energized by a control circuit. In addition to the S and P contactors, an assembly of four traction motor field shunting (M) contactors is operated by a single magnet valve.

606. **Traction Motor Circuits**

The four traction motors are shown in Figs. 6-1 to 6-4. When the manual transition lever is placed in position No. 1, control circuits cause S14 and S23 to close, setting up the series-parallel motor connections shown in Fig. 6-1. When the transition lever is moved No. 2 position the S and P contactors remain the same but the M contactors close. This action shunts part of the current around the traction motor field windings, allowing more amperage to flow through the armatures and thus obtaining greater speed from the traction motors. The circuit is illustrated in Fig. 6-2. Moving the transition lever to No. 3 position opens the S contactors and closes the P contactors. The shunting contactors also open and the parallel circuit shown in Fig. 6-3 is established. In transition lever position No. 4, the M shunting contactors again close as in No. 2 position and set up the parallel shunt circuit illustrated in Fig. 6-4.

On locomotives equipped with automatic transition, exactly the same circuits are set up, but the change from one to the other is effected by automatic means instead of movement of the transition lever as described. The equipment which accomplishes the transition or change is described under "Automatic Transition."(See Art.621)

On locomotives arranged for dynamic braking, the traction motors are converted into generators during dynamic braking.

LOW VOLTAGE SYSTEM

607. The low voltage system on the locomotive operates at 74 volts. It is used for lighting, operation of steam generators and to control the opening and closing of contactors, relays and switches. A contactor as used on the locomotive is a heavy duty switch remotely controlled. A relay is a light duty switch remotely controlled. Its purpose is to "re-lay" or re-direct the flow of current, or in many cases simply to close a circuit at some distant point either automatically or as a result of manipulation of controls.

608. The BATTERY is the source of low voltage current if the engine is stopped and supplies current for starting the engine. The auxiliary generator supplies the low voltage current when the engine is running.

609. The AUXILIARY GENERATOR charges the battery and carries the entire low voltage current load which otherwise would be supplied by the battery (See Art. 703).

610. The VOLTAGE REGULATOR is connected in the auxiliary generator circuit and maintains its voltage at 74 volts by varying the field strength of the auxiliary generator.

611. A REVERSE CURRENT RELAY is connected to the auxiliary generator circuit so that when the voltage is high enough to charge the battery and supply the low voltage circuits the auxiliary generator is automatically connected to the rest of the low voltage system.

612. The BATTERY CHARGING CONTACTOR connects the auxiliary generator to the rest of the low voltage system. It is controlled by the Reverse Current Relay. When the reverse current relay closes, the Battery Charging Contactor Coil is energized and closes the contactor. When the Reverse Current Relay opens due to failure of the auxiliary generator or shutting down the engine the Battery Charging Contactor opens and prevents a reverse flow of current into the auxiliary generator which would discharge the battery and damage the auxiliary generator.

613. An AUXILIARY GENERATOR SWITCH is installed so that the auxiliary generator may be manually disconnected from the low voltage system if so desired.

614. The AUXILIARY GENERATOR AMMETER shows the output of the auxiliary generator. The alternator field is directly connected to the ammeter shunt so that the ammeter will show a charge of 20-30 amperes even when the auxiliary generator switch is open. An auxiliary generator failure will result in an "Alternator Failure" alarm.

615. The AUXILIARY GENERATOR FIELD FUSE, 30 amperes, when blown stops output of auxiliary generator.

616. The AUXILIARY GENERATOR CHARGING FUSE, 150 amperes, when blown disconnects the auxiliary generator from the low voltage system but does not stop the auxiliary generator output to the alternator field. A 200 ampere fuse is used when a 3000 pound Steam Generator is installed.

617. Engine Starting Circuits

Two circuits are involved when the Engine is started. The first circuit closes the engine starting contactors (ST- and ST+ shown in Fig. 7-5, in each unit when the "ENGINE START" button is pressed in that unit. However, this circuit originates in the operating "A" unit of the locomotive and receives its electricity from the battery or auxiliary generator of the "A" unit. For this reason the following conditions are necessary in the "A" unit to start the engine in any unit.

1. Main battery switch closed (if engine in "A" unit is stopped.)
2. Auxiliary generator switch closed (if engine in "A" unit is running).
3. Main control switch closed on distribution panel.
4. Main control fuse (80 amp.) good.
5. Control switch closed in control push-button switch box.
6. Control fuse (30 amp.) good.
7. Isolation switch must be in "Start" position in each unit to be started.

The second circuit is set up when the starting contactors are closed. This circuit allows electricity from the storage battery to flow through the armature and the differential, commutating and starting field windings of the main generator. The generator operates as a motor to start the Diesel engine.

The circuit is entirely within the unit concerned.

To complete this circuit requires:

1. Main battery switch closed.
2. Starting fuse (400 ampere) good.
3. Starting contactors (ST- and ST+) closed.

618. **Engine Speed Control**

Movement of the throttle lever operates a drum contactor. In throttle positions 2 to 8, the contactor energizes one or more of four wires AV, BV, CV and DV, which run throughout the locomotive. In each unit taps from the wires run to the A, B, C and D solenoids in the Electro-hydraulic speed control section of the governor.

The table below shows the solenoids which are energized for each throttle position and the corresponding engine speeds.

ENGINE SPEED CHART

Throttle Position	Solenoids Energized A	B	C	D	Engine Speed RPM
OFF				*	STOP
IDLE		NONE			275
1		NONE			275
2	*				350
3			*		425
4	*		*		500
5		*	*	*	575
6	*	*	*	*	650
7		*	*		725
8	*	*	*		800
Effect of Solenoids on Engine RPM	+75	+300	+150	-150 (or stop)	

For operation of the engine speed control throughout the locomotive the operating "A" unit must have:

1. Main control switch closed.
2. Both control fuses (80 and 30 ampere), and fuel pump (15 ampere) good.
3. "Control" and "Fuel Pump" switches closed in control push-button switch box.
4. PC switch set.
5. Isolation switch in "Run" position (down) in each unit in which engine speed control is desired.

For operation of the speed control in any one unit, the ER relay must be energized and closed. The relay has contacts which open, when the relay is de-energized, and they interrupt the circuits supplying the A, B and C solenoids of the governor speed control. It has no effect on the circuit to the D solenoid. Thus, de-energizing the ER relay will cut out the A, B and C solenoids and bring the engine to idle speed if the throttle is in Runs 2, 3, 4, 7 or 8. Should the ER relay become de-energized when the throttle is in Run 5 or Run 6, the D solenoid will remain energized and cause the engine to stop.

The ER relays in the individual units are normally energized and closed by current received from the FP wire which runs throughout the locomotive. This wire is energized through the PC Switch (or Relay), Fuel Pump Switch and Fuel Pump Fuse. The ER relay in each unit will become de-energized from any of the following causes:

1. Isolation switch not fully in "RUN" position.
2. Failure of alternating current supply causing "No AC Voltage" relay to open.
3. Ground protective relay tripped.

Movement of the throttle to the "Stop" position energizes the D solenoids throughout the locomotive and stops all engines (when isolation switches are in run positions.)

A fifth solenoid (0) is included in the governor which effects engine loading only and does not change engine speed (See Art. 744).

619. Traction Motor Reversing Control

Movement of the reverse lever in the control stand into "forward" or "reverse" positions energizes the "FO" or "RE" wires throughout the locomotive. Taps from these wires, in each unit, lead to the "FOR" and "REV" magnet valve which, when energized, open and admit air to the cylinders operating the reverser drum.

Before reaching the contacts operated by the reverse lever, the current passes through the throttle control and transition control drum contactors in the control stand. The throttle must be opened to Run 1 and the transition lever in No. 1 position for operation of the reverser drums by reverse lever movement. That is, if the reverse lever is moved from "forward" to "reverse" with the throttle in "IDLE" or the transition lever in "OFF," the reverser drums will remain in "forward" position. As soon as the transition lever is moved to No. 1 position and the throttle opened to Run 1, the reverser drums will move to the reverse position. The generator field and control push-button switches and the main control switch must be closed in the operating "A" unit. The control fuses, (80 ampere and 30 ampere) must be good.

NOTE: On locomotives equipped with dynamic braking, the reverser drums will operate when the reverse lever is moved if the transition lever is in "OFF" position and the throttle in "IDLE." However, if the transition lever is moved to No. 1 and the reverse lever then changed, the reverser drums will not move until the throttle is opened to Run 1.

Movement of the reverse lever to neutral position has no effect on the reverser. It will however break the circuit to the S, P, SH and BF contactors. (When four long segments are showing on reverser drum the reverser is in forward position. When eight short segments are showing it is in reverse position.)

TRANSITION

620. The present production open circuit type transition is covered in this manual. Automatic transition includes the through cable type backward transition relays.

The following items are energized during both manual and automatic transition:

1. Parallel Relay. See Section 7, Art. 746.

2. Overriding Cylinder. See Section 7, Art. 745.
3. "M" contactor. See Section 7, Art. 763.
4. VT Relay. See Section 7, Art. 767.

In addition to the above items, the following relays are energized during automatic transition only:

1. Forward Transition Relay. See Section 7, Art. 729.
2. Backward Transition Relays - BTS, BTP. See Section 7, Art. 706.
3. Time Delay Relay - TD. See Section 7, Art. 758.
4. Time Delay Backward Relay - TDB. See Section 7, Art. 759.

621. Transition Sequence – Manual

FORWARD TRANSITION
(Train Speed Increasing)

It is to be assumed that engines have been started and put on the line and all controls and switches have been properly placed for normal operation.

1. No. 1 Transition Position (Series-Parallel):

   Transition lever placed in No. 1 position.

   a. Brake relay is de-energized.*
   b. Field loop and braking contactors open.*

   When throttle is opened to Run 1.

   c. Reverser moves to "FOR" or "REV."

*Indicates sequence only on Dynamic Brake equipped locomotives.

   d. Cam-switch moves to "motor" position.*
   e. "S" contactors close (S14 and S23).
   f. "SH" and "BF" contactors close. Throttle opened according to operating instructions, Section 1, Art. 151, to Run 8.

2. No. 2 Transition Position (Series-Parallel Shunt):

   When transition lever is moved to No. 2 position (Throttle in Run 8) —

   a. "M" contactors (M1, M2, M3, M4) close thus shunting the field of each traction motor.

3. No. 3 Transition Position (Parallel):

   When the transition lever is moved to No. 3 position (Throttle reduced to Run 6 just prior to making transition and opened again to Run 8 immediately after making transition) —

   a. Motor shunting contactor (M) opens.
   b. Parallel relay (PR) closes.
   c. Generator shunt field (SH) and battery field (BF) contactors open.
   d. Overriding solenoid (ORS) is energized.
   e. VT relay is energized. VT interlock CD opens 1/3 to 1/2 second later.
   f. S14 opens.
   g. P1 and P4 contactors close.
   h. S23 opens.
   i. P2 and P3 contactors close.
   j. Generator shunt field (SH) and battery field (BF) contactors close.
   k. Overriding solenoid (ORS) is de-energized.

*Indicates sequence only on Dynamic Brake equipped locomotives.

6

4. No. 4 Transition Position (Parallel-Shunt):

When the transition lever is moved to the No. 4 position (Throttle in Run 8) —

a. Motor field shunting contactors (M) close.

BACKWARD TRANSITION
(Train Speed Decreasing)

As train speed decreases due to a grade, the transition lever must be moved in accordance with transition meter indications to prevent overload of the electrical equipment. See Section 1 of this manual for operating details.

1. Parallel-Shunt to Parallel Transition

The following operations occur when the transition lever is moved from No. 4 to No. 3 position (Throttle in Run 8) —

a. "M" contactors open.

2. Parallel to Series-Parallel-Shunt Transition

When transition lever is moved from No. 3 to No. 2 position (Throttle reduced to Run 6 just prior to making transition and opened again to Run 8 immediately after transition is made) —

a. Parallel relay (PR) opens.
b. Generator shunt field (SH) and battery field (BF) contactors open.
c. Overriding solenoid (ORS) is energized.
d. P1, P4, P3 and P2 contactors open.

e. VT relay is de-energized.
f. S14 and S23 contactors close.
g. Generator shunt field (SH) and battery field (BF) contactors close.
h. Overriding solenoid (ORS) is de-energized.
i. "M" contactor closes.

3. Series-Parallel Shunt to Series-Parallel Transition

When transition lever is moved from No. 2 to No. 1 position (Throttle in Run 8) —

a. "M" contactors open.
b. "SH" and "BF" contactors remain closed.
c. "S14" and "S23" contactors remain closed.

4. Series-Parallel to "Off" Transition:

When throttle is moved to "IDLE."

a. "S14," "S23," "SH" and "BF" contactors open.

When transition lever is moved to "OFF."

b. Braking relay is energized, field loop contactor in lead unit closes, cam-switches move to "TOW" position, and braking contactors close.*

622. Automatic Transition

The automatic transition arrangement is self-contained in each unit and acts independently of the automatic transition in adjoining units.

*Indicates sequence only on Dynamic Brake equipped locomotives.

623. Transition Sequence — Automatic

Forward Transition

The transition lever is placed in No. 1 position and left in this position at all times the locomotive is operated in automatic transition.

When the throttle is opened to Run 1, SH and BF close through their regular circuit, energizing the fields of the main generator. S14 and S23 contactors close through their regular circuit, conducting the current from the main generator to the traction motors, which are connected in series-parallel, No. 1 transition position. The throttle is opened according to operating instructions, Section 1, Art. 151, to Run 8. The following transition sequences all take place with the throttle in Run 8.

1 to 2 When the speed of the locomotive has increased sufficiently, the generator voltage builds up to the pickup value of FTR. This relay energizes M contactor, closing the motor shunting contacts, changing the motor circuit to series-parallel-shunt, #2 transition position. FTR drops out as the generator voltage falls below the dropout value of FTR. M contactor remains energized through an established holding circuit.

2 to 3 When the generator voltage again builds up to the FTR pickup, this relay energizes PR relay. As PR is energized, SH, BF and M contactors are de-energized. S14 contactor opens after a 1/3 to 1/2 second delay through VT relay. P1 and P4 contactors close. S23 opens and P2 and P3 contactors close. FTR drops out as the generator voltage falls below the dropout value of FTR. PR contactor remains energized through its holding circuit. SH and BF contactors will close. The motor connections have been changed to parallel, #3 transition position.

3 to 4 With increasing locomotive speed the generator voltage will again build up to the FTR pickup value. The motor shunting contacts are again closed, changing the motor circuit to parallel shunt, #4 transition position. FTR does not drop out in this position as closed interlocks on TDB, PR and M short out some resistance in the FTR circuit, lowering its dropout values.

Backward Transition

4 to 3 When the locomotive speed decreases, due to an ascending grade, the generator current increases and the voltage drops below the drop out value of FTR. As FTR drops out, M contactor is de-energized, opening the motor shunting contacts, changing the motor circuits back to parallel, #3 transition position.

3 to 2 A further decrease in locomotive speed will result in an increased generator current output. BTS and BTP (backward transition relays) are energized when the generator current reaches their pickup value, de-energizing PR relay. With PR de-energized, SH, BF and all four P contactors open. S14 and S23 contactors close. SH and BF will close again. The generator voltage will immediately rise to the FTR pickup value, energizing M contactor, closing the motor shunting contacts. The motor connections have now been changed back to series-parallel shunt, #2 transition position.

2 to 1 With a still further reduction in locomotive speed, the generator current will reach the pickup value of BTS, which has a lower setting than BTP. When BTS picks up it de-energizes M contactor, opening the motor shunting contacts. The motor circuits have been changed back to series-parallel, #1 transition position.

Automatic transition may be cut in or out in any unit by switches located in the electrical control cabinet. When cut out, the unit will respond to manual transition control as described under that subject. If the automatic transition is cut out on one unit of the locomotive it must be cut out on all other units of the locomotive, and the locomotive must be handled by manual transition. The automatic transition is cut out on units so equipped when the locomotive contains a unit without automatic transition, or in which the automatic transition has become inoperative.

MAIN GENERATOR FIELD EXCITATION

624. The excitation of the battery and shunt field windings only are covered below. The "starting" field has been described under "ENGINE STARTING CIRCUITS." The differential and commutating fields are permanently connected.

625. Battery Field

The battery field of the main generator is excited by low voltage electricity. The circuit is established by the closing of the battery field contactor and varied in strength by the load regulator.

626. BATTERY FIELD CONTACTOR. In each unit, the contactor is operated by a tap from the GF wire running throughout the locomotive. To energize the GF wire, the cab and electrical control cabinet of the operating "A" unit must have:

a. Main control switch closed.
b. Control push-button switch closed.
c. Generator field push-button switch closed.
d. Transition control in No. 1 position or higher.*
e. Throttle in Run 1 or higher.
f. Main control fuse (80 amp.) good.
g. Control fuse (30 amp.) good.

* Step "d" necessary because of mechanical interlock in control stand which prevents opening of throttle with transition lever in "OFF."

In each unit, the following conditions are necessary to close the battery field contactor when wire GF is energized.

h. Starting contactors "ST-" and "ST+" open (interlocks closed).
i. Cam-switch in "MOTOR" position (interlock closed).
j. Ground relay set.
k. Parallel relay de-energized, P3 contactor open, and S14 and S23 closed, or parallel relay energized and P3 contactor closed.
l. Wheel slip relays de-energized.
m. Shunt field contactor closed (interlock closed).
n. When the battery field contactor is closed as above, electricity from the low voltage supply of the individual unit energizes the main generator battery field. A Battery Field Fuse (80 amp.) is included in this circuit.

627. LOAD REGULATOR. The load regulator is a device which loads the engine according to the throttle setting in the cab. It automatically maintains a constant horsepower output corresponding to each throttle position over the entire range of locomotive speeds.

For the purpose of load regulation, determination of the horsepower output of the engine is based on the rate of fuel consumption. This is determined by the relationship between the speed setting on the governor and the position of the power piston controlling the opening of the injector racks. If the engine demands more fuel than a predetermined setting or balance point, the load regulator reduces the load on the engine by reducing the field excitation (battery field) of the main generator, thereby reducing its power output.

If the engine requires less fuel than the predetermined setting, the load regulator increases the load on the engine by increasing field excitation of the main generator. In this manner, battery voltage, temperature changes in generator windings, or locomotive speeds do not cause overloading or underloading of the engine and a constant horsepower output is maintained for each throttle setting.

The load regulator has two components: first, the pilot valve which is in the governor, and second, a self-contained unit which consists of an hydraulic rotary vane type motor attached to the commutator type rheostat. The only external wiring connections are two leads to the generator battery field circuit.

A solenoid (ORS) in the governor is energized during the time interval in which transition from 2 to 3 or 3 to 2 is taking place. The operation of this solenoid causes the load regulator to move toward minimum field in this period.

628. **Shunt Field**

The shunt field is connected across the armature and commutating, compensating and differential fields of the main generator. When the armature turns, it builds up voltage, causing current to flow through the shunt field windings. The circuit contains the shunt field contactor which must be closed to establish the circuit. The electricity which operates the shunt field contactor in each unit follows the same path as the current for the battery field contactor above as far as a branching point where the flow divides. One branch goes to the battery field contactor, through an interlock on the shunt field contactor. The other wire runs to the operating coil of the shunt field contactor. Thus the requirements for battery field contactor operation apply to the shunt field contactor, up to (item m) of Art. 626.

FUEL PUMP OPERATION

629. The fuel pump circuits are two in number:

1. A control circuit by which the pumps are started and stopped simultaneously from the operating "A" unit by energizing or de-energizing wire "FP" throughout the locomotive. In each unit, taps from FP operate a relay called the "Fuel Pump Contactor" to establish the second, or operating circuit in that unit.

   To energize wire "FP," the following conditions are required in the operating "A" unit.

   a. Main control switch closed.
   b. Main control fuse (80 amp.) good.
   c. Fuel pump push-button switch in.
   d. Fuel pump fuse (15 amp.) good.
   e. PC switch set.

2. The operating circuit in each unit draws its current from the low voltage supply to run the fuel pump motor. A fuel pump motor fuse is included in this circuit. It is located on the distribution panel in the electrical control cabinet. A fuel pump switch is provided on the engine control and instrument panel. By this switch, the individual fuel pump may be started or

stopped if the control circuit above is energized. If the control circuit is dead, the pump cannot be started by closing the fuel pump switch. The engine temperature control circuit is tapped from this circuit below the Fuel Pump Switch.

NOTE: That there are two Fuel Pump Fuses on the Distribution Panel. One labelled "Fuel Pump" is in the Fuel Pump Control Circuit. The other is labelled "Fuel Pump Motor" and is in the operating circuit of that unit.

ENGINE TEMPERATURE CONTROL

630. Two engine temperature control systems are in use on different model F3 locomotives. On those locomotives built prior to October 1, 1947, the engine temperature control system included a Summer-Winter Selector Switch and two transfer relays. The Summer-Winter switch was installed in the shutter magnet valve circuit. It changed the circuit so that in Summer position the shutters opened at 166° before any cooling fans started. In Winter position the circuit was such that the shutters opened when the third fan (not necessarily No. 3 fan) started. The transfer switches were arranged in the circuit so that the sequence in which the cooling fans were actuated was changed each time a new cycle of the cooling fan circuit was started. The fan and shutter control circuit on this type of installation is given in (7) below.

The cooling fan circuit on locomotives produced since October 1, 1947 had the functions of the Summer-Winter selector switch and the transfer relays combined in one manually operated switch. The temperature at which the shutters open is changed as in the earlier type installation so that the shutters open at 166° in Summer position and at 175° in Winter position (simultaneously with No. 3 fan). However the transfer relays have been deleted and a transfer portion (manually operated as a part of Summer-Winter transfer switch) incorporated which changes the fan sequence from 1, 2, 3, 4 in Summer position to 4, 2, 3, 1 in Winter position. It has been found unnecessary to change the fan sequence each time the temperature control system cycles. The fan and shutter control circuit on this type of installation is given in (8) below.

The engine temperature control circuit supply is tapped from the fuel pump motor line. Thus all the information under Fuel Pump Operation on both control and operating circuits, applies directly to the cooling fan motors. In addition, the engine temperature control circuit includes:

1. THERMOSTAT SWITCH, (See Art. 755) operated by the temperature of the engine cooling water. As the temperature rises, successive contacts close in the switch at 3° intervals. The contacts complete circuits which open the shutters and energize the cooling fan motor contactors one by one.

2. The TEMPERATURE CONTROL RELAY (TCR) is actuated by the thermostat switch. When the No. 2 contact on the thermostat switch closes at 166° TCR closes and remains closed until temperature drops to 163°, when the No. 1 contact on the thermostat switch opens and drops TCR out. TCR serves the following purposes:

   a. Opens shutters (summer position) at 166° by energizing the shutter magnet valve.

   b. Establishes a holding circuit for the AC motor contactors so that as each fan starts it remains running as long as TCR remains closed. TCR drops out at 163° when No. 1 contact on the thermostat switch opens. This closes the shutters and stops the cooling fans since the circuits for this equipment were completed through TCR.

c. On locomotives built prior to October 1, 1947, it actuates the Transfer Relays to change the operating sequence of the cooling fans.

3. The SHUTTER MAGNET VALVE controls the air supply which opens the shutters in the cooling system. It is located on the left side wall of the locomotive near the engine blower. An air shutoff valve is near the magnet valve.

4. AC MOTOR CONTACTORS. These are numbered from left to right when facing panel and operate motors with same number. When energized as in No. 1 above the contactors close and allow alternating current from the alternator to operate the cooling fan motors. (Some contactors are equipped with two thermal overload devices for protection against motor overload. In case of such an overload, a thermal element melts and allows a ratchet device to open the contactor operating circuit and stop the fan motor. If this should occur, allow a few minutes for the alloy to cool and solidify before pushing "in" on the reset button. If a contactor trips the second time within a short interval, do not attempt to reset it. This should be reported at the first maintenance point. If for any reason it should become necessary to cut out one cooling fan motor this may be done by manually tripping the thermal overload devices by depressing the small plated release fingers beside the reset buttons.)

5. TRANSFER RELAYS. (On locomotives built prior to October 1, 1947). The sequence of operation of the four cooling fans is changed by

operation of the transfer relays. This is provided so that all four fans will get approximately equal work to avoid the probability of the last fan never working. One relay controls fan motors Nos. 1 and 4, the other controls fan motors Nos. 2 and 3.

6. SUMMER-WINTER TRANSFER SWITCH (used on locomotives built after October 1, 1947). This switch combines the functions of the Transfer Relays and Summer-Winter Selector Switch mentioned above and replaces these switches on locomotives built after October 1, 1947. The position of this switch is changed from Summer to Winter periodically. In the summer position it arranges the circuits so that the shutters open before any of the cooling fans come on. In the winter position it arranges the circuits so that the shutters open when the No. 3 fan comes on. It also changes the sequence of fan operation from 1, 2, 3, 4 in summer position to 4, 2, 3, 1 for winter position.

7. FAN AND SHUTTER CONTROL CIRCUIT (with Summer-Winter Selector Switch and Transfer Relays - before October 1, 1947). The sequence of operation of this circuit begins with water temperature below 163° F. When the temperature rises:

a. At 163° the No. 1 contact on the thermostat switch closes. There is no further action at this temperature.

b. At 166° the No. 2 contact on the thermostat switch closes and this energizes the Temperature Control Relay (TCR). When TCR closes it:

(1) Establishes a holding circuit for itself through the No. 1 contact of the thermostat switch (interlock CD).

(2) It energizes the two transfer relays TR1 and TR2 through the TCR interlocks AB and EF (this changes fan sequence from sequence of previous cycle).

(3) (Summer position only). It energizes the shutter magnet valve through the TCR interlock and the shutters open.

c. At 169° the No. 3 contact on the thermostat switch closes. This energizes AC motor contactor AC4 (or AC1 depending on position of transfer relay) through the transfer relay to the operating coil of AC4 and to the negative wire through the thermal overload switches TO4. One interlock of AC4 is in this circuit. A second coil used for both operating and holding AC4 is tapped off just below the transfer relay to form a parallel circuit. Thus two coils in parallel are used to close the AC motor contactor. When AC4 closes the interlock in the operating coil circuit opens and the contactor is held closed only by the second coil of the circuit. When AC4 closes it also closes an interlock to the TCR circuit so that AC4 will be held closed as long as TCR is closed. Closing AC4 starts the No. 4 fan motor.

d. At 172° No. 4 contact on the thermostat switch closes and a circuit through TR2 closes AC3 (or AC2) in the same manner as AC4 was closed above and No. 3 fan motor starts.

e. At 175° No. 5 contact on the thermostat switch closes and AC2 closes starting No. 2 fan motors. (Note: With winter setting shutters open at this temperature when No. 5 contact closes).

f. At 178° No. 6 contact on the thermostat switch closes and AC1 closes starting No. 1 fan motor.

g. As the temperature starts to descend No. 6 contact on the thermostat switch will open but AC motor contactors are held in through the holding circuit established by each AC contactor when it closed and the AB interlock on TCR. Thus the fans which had started will continue to run as the temperature drops and the thermostat switch opens contacts 6, 5, 4, 3, 2. At 163° No. 1 contact on the thermostat switch opens and TCR drops out. When this occurs all the fan motors will stop and the shutters will close. The cycle is now ready to repeat itself as the temperature again rises.

h. The cycle may be completed with only the shutters or the shutters and from 1 to 4 fan motors operating. It is uncommon for all four fan motors to start before the temperature begins to drop.

i. In the winter time a somewhat different sequence is used. The shutters are set by means of a throw over switch so that they open when the third motor has started. This is accomplished by hooking one lead from the switch in the SMV wire to the No. 5 contact of the thermostat switch.

8. FAN AND SHUTTER CONTROL CIRCUIT. (With Summer-Winter Transfer Switch - after October 1, 1947. The sequence of operation of this circuit begins with water temperature below 163° F. When the temperature rises:

a. At 163° the No. 1 contact on the thermostat switch closes. There is no further action at this temperature.

b. At 166° the No. 2 contact on the thermostat switch closes and this energizes the Temperature Control Relay (TCR). When TCR closes it:

(1) Establishes a holding circuit for itself through the No. 1 contact of the thermostat switch (interlock CD).

(2) (Summer position only.) It energizes the shutter magnet valve through the TCR interlock and the shutters open.

c. At 169° the No. 3 contact on the thermostat switch closes. In summer position this energizes AC motor contactor AC1 (through a circuit passing through the Summer-Winter Switch to an AC1 interlock to the AC1 operating coil to negative). A second coil used for both operating and holding AC1 is tapped off just below the transfer switch to form a parallel circuit. Thus two coils in parallel are used to close the AC motor contactor. When AC1 closes the interlock in the operating coil circuit opens and the contactor is held closed only by the second (holding) coil of the circuit. When AC1 closes it also closes an interlock to the TCR circuit so that AC1 will be held closed as long as TCR is closed. Closing AC1 starts the No. 1 fan motor.

d. At 172° No. 4 contact on the thermostat switch closes and a circuit closes AC2 and No. 2 fan motor starts.

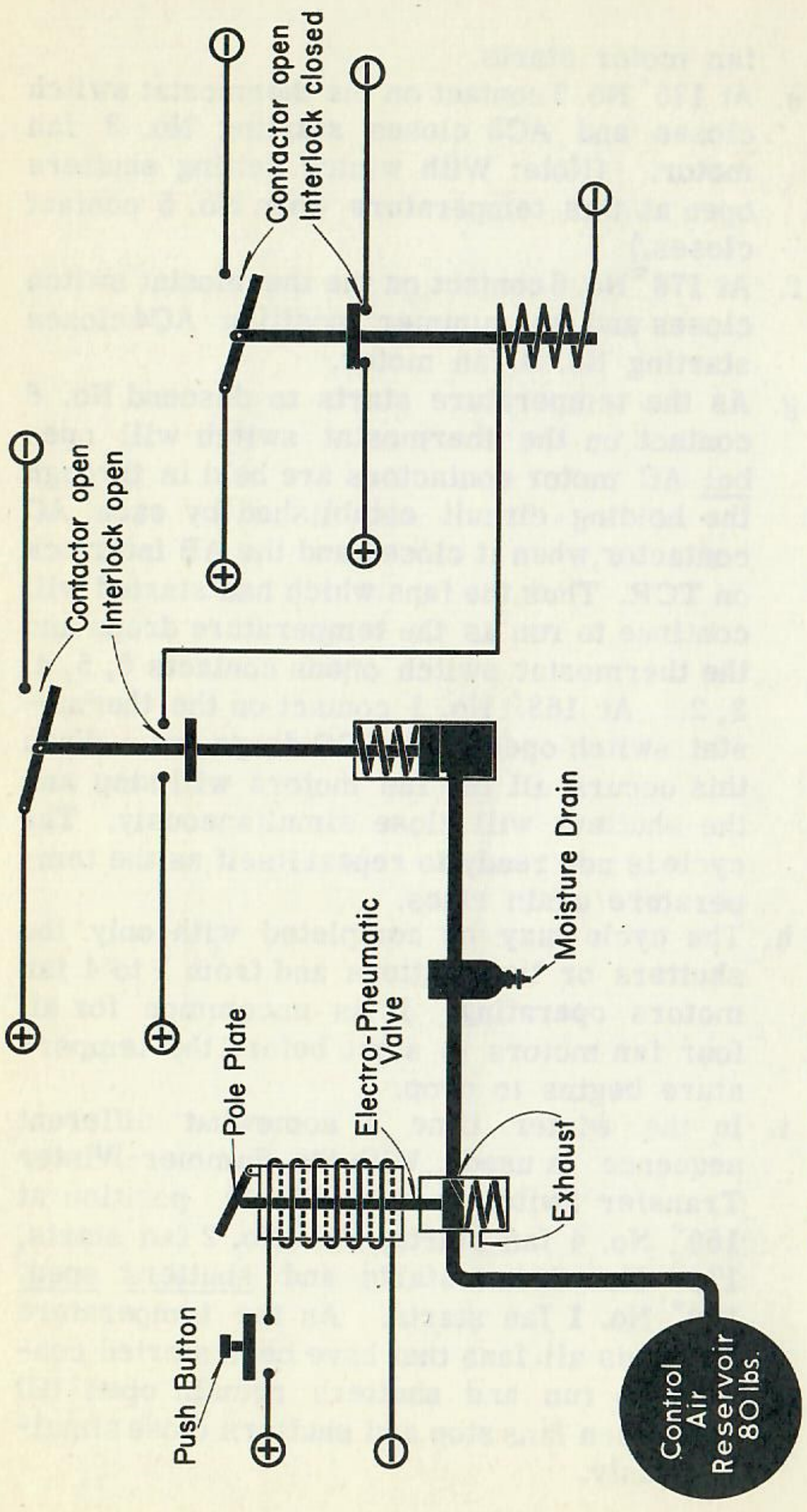
e. At 175° No. 5 contact on the thermostat switch closes and AC3 closes starting No. 3 fan motor. (Note: With winter setting shutters open at this temperature when No. 5 contact closes.)

f. At 178° No. 6 contact on the thermostat switch closes and in summer position AC4 closes starting No. 4 fan motor.

g. As the temperature starts to descend No. 6 contact on the thermostat switch will open but AC motor contactors are held in through the holding circuit established by each AC contactor, when it closed, and the AB interlock on TCR. Thus the fans which had started will continue to run as the temperature drops and the thermostat switch opens contacts 6, 5, 4, 3, 2. At 163° No. 1 contact on the thermostat switch opens and TCR drops out. When this occurs all the fan motors will stop and the shutters will close simultaneously. The cycle is now ready to repeat itself as the temperature again rises.

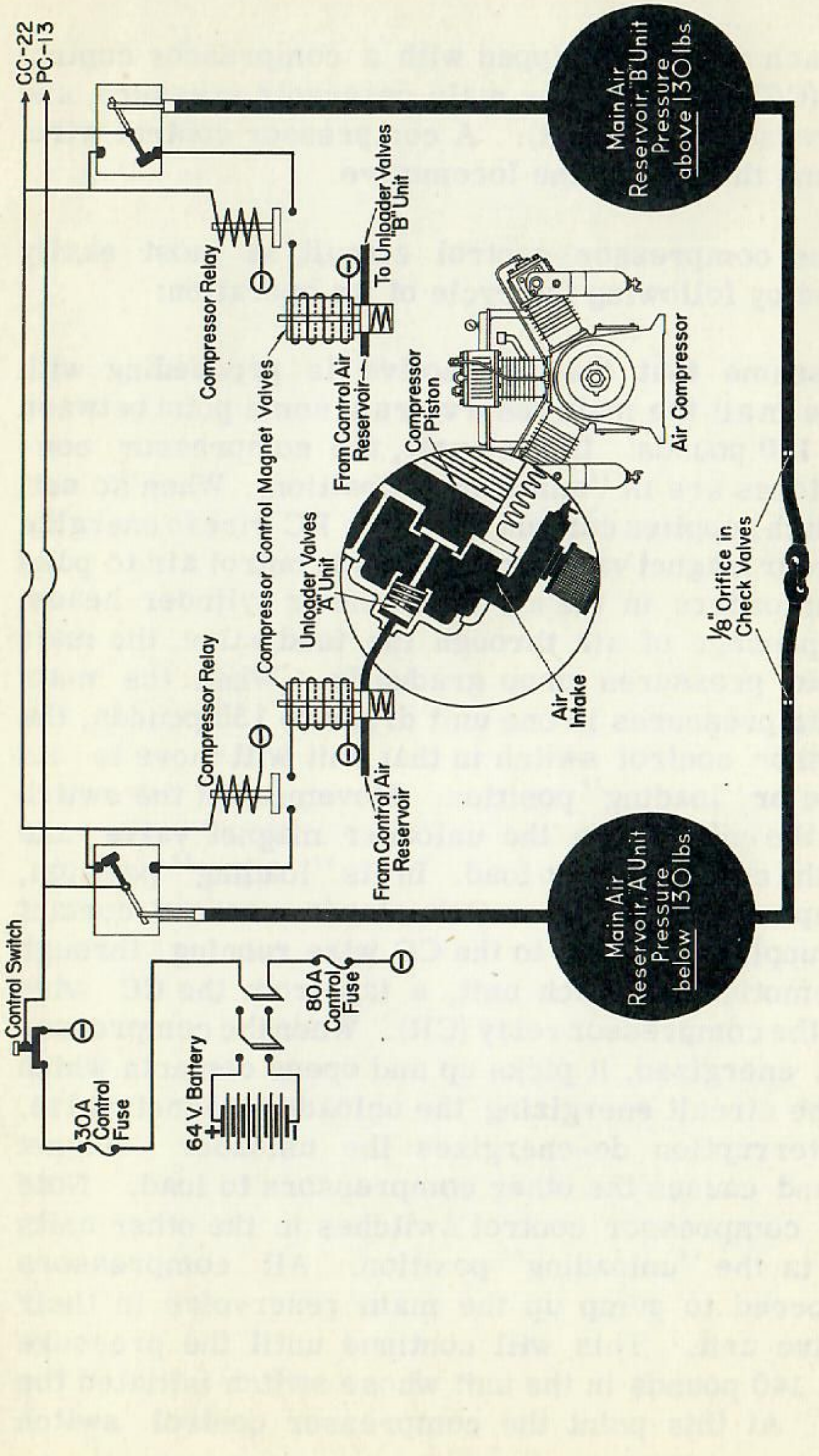
h. The cycle may be completed with only the shutters or the shutters and from 1 to 4 fan motors operating. It is uncommon for all four fan motors to start before the temperature begins to drop.

i. In the winter time a somewhat different sequence is used. With the Summer-Winter Transfer Switch in the Winter position at 169° No. 4 fan starts, 172° No. 2 fan starts, 175° No. 3 fan starts and shutters open. 178° No. 1 fan starts. As the temperature descends all fans that have started continue to run and shutters remain open till 163° when fans stop and shutters close simultaneously.


Contactor open
Interlock closed
Contactor open
Interlock open
Moisture Drain
Electro-Pneumatic Valve
Pole Plate
Exhaust
Push Button
Control Air Reservoir 80 lbs.

BASIC ELECTRO-PNEUMATIC AND ELECTRO-MAGNETIC CONTACTORS AND INTERLOCKS

Fig. 6-5


CC-22
PC-13
Main Air Reservoir 'B' Unit Pressure above 130 lbs.
To Unloader Valves 'B' Unit
Compressor Relay
Compressor Control Magnet Valves
From Control Air Reservoir
Compressor Piston
Air Compressor
1/8" Orifice in Check Valves
Unloader Valves 'A' Unit
Compressor Control Magnet Valve
Compressor Relay
Air Intake
From Control Air Reservoir
Main Air Reservoir 'A' Unit Pressure below 130 lbs.
Control Switch
80A Control Fuse
30A Control Fuse
64 V. Battery

COMPRESSOR CONTROL
"A" & "B" UNITS, F3 LOCOMOTIVES
SHOWN IN PUMPING POSITION

Fig. 6-6

COMPRESSOR CONTROL

631. Each unit is equipped with a compressor control switch, (CCS), actuated by main reservoir pressure, and a compressor relay, (CR). A compressor control wire, (CC), runs throughout the locomotive.

The compressor control circuit is most easily explained by following the cycle of its operation:

Assume that the locomotive is proceeding with pressure in all the main reservoirs at some point between 130 and 140 pounds. In each unit, the compressor control switches are in "unloading" position. When so set, each switch supplies current from the PC wire to energize an unloader magnet valve which allows control air to pass to the unloaders in the air compressor cylinder heads. Due to passage of air through the feed valve, the main reservoir pressures drop gradually. When the main reservoir pressures in one unit drops to 130 pounds, the compressor control switch in that unit will move to its alternate or "loading" position. Movement of the switch breaks the circuit to the unloader magnet valve and causes the compressor to load. In its "loading" position, the compressor control switch closes a second contact which supplies current to the CC wire running through the locomotive. In each unit, a tap from the CC wire runs to the compressor relay (CR). When the compressor relay is energized, it picks up and opens contacts which are in the circuit energizing the unloader magnet valve. This interruption de-energizes the unloader magnet valves and causes the other compressors to load. Note that the compressor control switches in the other units remain in the "unloading" position. All compressors then proceed to pump up the main reservoirs in their respective unit. This will continue until the pressure reaches 140 pounds in the unit whose switch initiated the loading. At this point the compressor control switch will move back to its "unloading" position. The movement will de-energize the CC wire and also the compressor relays in all units. All compressors will unload and remain so until the main reservoir pressure again drops to 130 pounds in one unit. Note that, under this system, it is possible, for the main reservoir pressure to rise above 140 pounds in the units other than the one responsible for the loading.

Control current from the push button at the engineer's station is necessary to unload the compressors. In the event of a circuit failure the air compressors will not unload but will pump continuously.

ALARM AND PROTECTIVE CIRCUITS

632. "Hot Engine" (See Art. 212).

When the temperature of the engine cooling water rises above a predetermined figure, the Engine High Temperature Alarm Switch closes. This allows current from the PC wire to pass through and illuminate the red "HOT ENGINE" lights in that unit and energizes the signal relay operating coil. When the signal relay picks up, it closes contacts which allow electricity from the PC wire to operate the alarm bell in that unit. The same circuit also energizes SG wire throughout the locomotive, ringing the alarm bells in the other units as well.

633. "Low Oil" (See Art. 212).

In case of low lubricating oil pressure or high lube oil pump suction, a switch in the governor closes. This lights the yellow "LOW OIL" alarm lights and rings the alarm bells as described under "HOT ENGINE."

634. "Boiler Stopped"

If the steam generator stops, the boiler alarm relay will close and actuate the alarm system in the same manner as above.

635. "Alternator Failure" (See Art. 212).

Should the alternator voltage fall below a predetermined figure, the "No AC Voltage" relay will drop out. The relay has three sets of contacts, one set when open interrupts the circuit to the "ER Relay." With "ER Relay" de-energized, the A, B and C solenoids in the governor will be de-energized and the engine speed will drop to idle. If engine throttle is in the 5th or 6th position at this time, the D valve will remain energized and the engines will stop. The second set will close, lighting the "Alternator Failure" light. The third set will close, energizing SG wire to ring the alarm bells in all units of the locomotive.

636. Wheel Slip Indicator (See Art. 764).

When one pair of wheels slip, one of the two wheel slip relays will pick up due to a difference in potential of the points across which it is connected. Contacts close which energize the WS wire throughout the locomotive. Taps from WS illuminate the wheel slip indicator lights in the cabs of all "A" units whether operation is being handled from that end or not.

When picked up, a second pair of contacts close which by-pass the operating coil of the shunt field contactor. This opens the shunt field contactor, and, consequently, the battery field contactor. The main generator output is reduced and the power applied to the slipping pair of wheels drops. As soon as the slipping stops, the wheel slip relay drops out and power will be restored.

Two wheel slip relays are provided per unit, one across No. 1 and No. 4 traction motors and the other across No. 2 and No. 3 motors. The light will not burn continuously when wheels slip, because the wheels will not slip continuously. The connections of the wheel slip relay to the power plant are such that the power is automatically reduced when the wheels slip. Therefore, the wheels will slip, then stop, slip again and stop — about once a second.

When there is a wheel slip indication, it will probably be only one set of wheels that are slipping, unless the rail conditions are extremely bad. On these locomotives with many traction motors, all of which exert their tractive effort independently, with the connections as outlined above, a wheel slip indication usually means only a partial and temporary loss of tractive effort.

It is, therefore, unnecessary to use sand except under the worst track conditions. Before applying sand, be sure to reduce the throttle until the wheel slip light stops flashing. It should be remembered that sand is injurious to the traction motors and associated equipment.

If one pair of wheels is locked, due to a broken pinion or axle gear, or the armature shaft frozen in its bearings, the wheel slip signal will light and will stay on as long as current is being supplied to the motors. This is true except in the case of very low locomotive speeds due to the fact that a definite difference in potential between the traction motors is required to make the wheel slip relay function with the motor circuit in the series parallel or parallel position. Therefore, the locomotive speed must be great enough to bring about this difference in potential for any wheel slip indication to be given.

During transition from 2 to 3 or 3 to 2, the wheel slip relay will pick up, causing the wheel slip light to flash. This is not an indication that the wheels are slipping.

The wheel slip relay will give protection in all "Transitions." Should axles 1 and 4 or 2 and 3 on any unit slip simultaneously, no wheel slip relay action will result.

637. **Ground Protective Relay** (See Arts. 224, 732)

One terminal is connected to the terminal of the shunt field contactor. The other terminal is grounded to the carbody. In case of a ground in the high voltage electrical system, the current will travel through the carbody structure and complete the circuit to energize the ground relay. When tripped, contacts in the ground relay open which de-energize the "ER Relay" and the shunt and battery field contactor operating coils. The engine speed will drop to idle and contactors will open. This is another instance where the D valve will stay energized if the engine throttle is in the 5th or 6th notch and the engines will stop.

The ground protective relay will trip in case of a ground in the low voltage system only when the engine is being started.

If relay trips see Art. 224.

ALTERNATING CURRENT CIRCUITS

638. Alternator

The alternator is built into the same frame as the main generator. It consists of a stator and rotating part or rotor. In the alternator, the rotor acts as a rotating field winding and the current is produced in the stationary part or stator. It is a 16 pole, 3 phase, 149 volt Y connected assembly driven at engine speed. The stator is bolted directly to the main generator frame; the rotor, or rotating field is bolted directly onto the Main Generator Armature and lies between the main generator and the engine. Two slip rings for field excitation are mounted on the front of the main generator next to the compressor coupling. The field excitation is furnished by the auxiliary generator and is constant. Voltage, therefore, varies slightly with load, and practically directly with engine speed. The frequency varies with engine speed and is 106-2/3 cycles per second at 800 RPM and 36-2/3 cycles per second at 275 RPM.

639. Alternator Field Excitation

The rotating field of the alternator is excited by low voltage direct current circuit supplied by the auxiliary generator and protected by a 35 amp. fuse. Note that the leads for this current are so connected that the auxiliary generator switch, reverse current relay, battery charging contactor or battery charging fuse (150 amp.) are not in this circuit. An open circuit at any of these points will not interfere with alternator field excitation but a blown auxiliary generator field fuse will. Also in case of an auxiliary generator failure, the alternator field excitation cannot be supplied by the storage battery as can the other low voltage circuits.

640. Traction Motor Blowers

The traction motor blowers are driven by four 3 phase, 149 volt, 5 HP, 3100 RPM (At full engine speed) 4 pole induction motors which are permanently connected to the alternator and operate continuously as long as the engine is running. All the AC motors are simple in construction, rugged and durable. They are devoid of commutators, slip rings, and brushes. In each case, the fan or blower wheel is mounted directly on the motor shaft. The speed of the blower motors is proportional to engine speed.

641. Engine Cooling Fans

The cooling fans are driven by four 3 phase, 149 volt, 8 pole, 9 HP induction motors which run at 1550

RPM at full engine speed, and at 530 RPM at idle engine speed (early models have 12 HP, 10 pole, 1250 - 430 RPM motors). They are mounted in the main hatch directly over the engine with shafts vertical. The fans are mounted directly on the motor. Operation of each fan is controlled individually by its contactor which, in turn, is controlled through the automatic temperature control. The cooling fan motors are totally enclosed. Fans are numbered 1, 2, 3, 4 from front of unit. (See Arts. 630 and 108.)

DYNAMIC BRAKING

642. When the locomotive is changed from power operation to dynamic braking three general changes are made.

1. The traction motor field windings are disconnected from the armatures. The fields of the four traction motors in each unit are hooked up in series and connected across the main generator.
2. Each traction motor armature is connected to a separate resistance or "grid" located in the top of the locomotive carbody when cam switch is in "TOW" position.
3. The battery field windings of all the main generators in the locomotive are connected in series and energized by current supplied from the operating "A" unit. This is called the Field Loop circuit. The volume of current is controlled by the movement of the transition lever in the dynamic braking range, the lever operating a variable resistance in this circuit.

With the above changes, the operating principle of the dynamic brake is:

1. The main generators produce electricity to excite the field windings of the traction motors. This output will depend on the excitation of the main generator which will be varied by the operation of the transition lever as in 3 above.
2. The traction motors will act as separately excited generators, driven by the push of the train. The output of the armatures will be governed by the amount of excitation current supplied by the mair generator. The greater the excitation, the more current the armatures will generate and feed to the grids. This will require more power to drive the traction motors, and hence exert a greater "holding back" effect on the train. The current output of the No. 1 and No. 3 traction motor armatures also supplies electricity to run motors which drive fans cooling the grids.

643. Cam-Switch Operation

When the transition lever is moved from No. 1 to "OFF" position, a contact in the control stand energizes wire "B" throughout the locomotive. In each unit, taps from wire "B" energize the brake relay (BR). When so closed, the brake relay completes a circuit which energizes a magnet valve (TOW), admitting air to move the cam-switch to "TOW" position. In this position, the cam-switch disconnects the traction motor armatures from the fields and connects them to the grids.

644. Braking Contactor Operation

Closing of the brake relay also completes the circuit which closes the braking contactors, (B1, B2 and B3). The braking contactors connect the four traction motor fields in series across the armature of the main generator. The circuit operating the braking contactors contains interlocks which require seven conditions to exist before the circuit is completed.

1. Transition lever in "OFF" position.
2. Brake relay energized.
3. Cam-switch in "TOW" position.
4. P2 contactor open.
5. P4 contactor open.
6. Reverser drum in position corresponding to position of reverse lever.
7. Isolation switch in "RUN" position.

645. **Field Loop Circuit**

The movement of the cam switch to "TOW" position partially sets up the field loop circuit which energizes the battery field windings of all the main generators in the locomotive. Contacts on the cam-switch in each unit disconnect the main generator battery field from its power operation leads and connect it in the field loop circuit.

A further step in the establishment of the field loop circuit is accomplished by the closing of the field loop contactor in the operating "A" unit only. The field loop contactor is operated by a circuit which is energized when the transition lever is moved to "OFF" position and the reverse lever placed in forward or reverse position. The field loop contactor cuts in the brake control rheostat, operated by the transition lever and the unit selector switch.

The purpose of the unit selector switch is to provide the same resistance in the field loop circuit whether the locomotive consists of one, two, three or four units. If less than four units are present, the unit selector switch introduces resistances into the circuit which compensate for the lower number of main generator field windings in series. It should be noted that this provides the reason why, when one unit is isolated, the unit selector switch is not changed. Even when isolated, the main generator field is still in the field loop circuit.

When the transition and dynamic brake lever is further moved to the "B" position, a contact in the control stand energizes wire "BG" through the locomotive. In each unit, a lead from "BG" energizes the battery field contactor. Closing of the battery field contactors completes the field loop circuit. The battery fields of all generators are now connected in series and energized from the operating "A" unit.

If the trailing unit is a "B" unit, a shorting bar will close the field loop when the jumper is removed from the unit. If for any reason the shorting bar does not make contact, the dynamic brake will not function as there will be no field loop circuit. If the trailing unit is an "A" unit, the field loop contactor remains de-energized and in this position closes the field loop circuit.

If the isolation switch on any unit of a multi-unit locomotive is placed in "START" position, dynamic braking will be ineffective on that unit only. The selector switch is always left in the position corresponding to the NUMBER of units making up the locomotive.

If the engine in the leading "A" unit is isolated and shut down, battery current will excite the main generator fields, completing the Field Loop circuit as long as the main battery switch is closed and current continues to flow from the battery.

6

NOTES

SECTION 7

UNITS OF THE ELECTRICAL SYSTEM

700. Alarm Signal Relay

This relay operates with the signal lights ("Hot Engine," "Boiler Off" and "Low Oil Pressure") to ring the alarm bells throughout the locomotive.

701. AC Motor Contactors (See Arts. 630, 301)

There are four of these contactors in the electrical control cabinet of each unit. Each radiator cooling fan motor is individually controlled by one of these contactors which in turn is controlled through the thermostat switch. (Also see "Operation of Cooling System" Section 3, and "Transfer Relays" in this section.)

Most of the AC fan motor contactors are provided with a thermal overload protective device. For information on operation of this protective device see Art. 630, Item 2.

702. Alternator (See Art. 638)

The alternator is a 100 KW, 149 Volt, 3 Phase unit built into the engine end of the main generator and supplies AC Power for the traction motor blowers and the radiator cooling fan motors.

703. Auxiliary Generator (See Art. 609)

The auxiliary generator is used for charging the locomotive storage batteries and to supply all the low voltage DC power when the locomotive is operating. This generator is direct driven through flexible couplings from the rear gear train of the engine. The voltage output of the auxiliary generator is maintained at a constant level of 74 volts by the voltage regulator.

704. **Auxiliary Generator Ammeter** (See Art. 614, 220)

The ammeter is located in Low Voltage panel of the electrical cabinet and shows output of Auxiliary Generator.

705. **Auxiliary Generator Switch** (See Art. 613)

One switch is located in the electrical control cabinet of each unit. All battery charging equipment of one power plant (auxiliary generator, reverse current relay, battery charging contactor, alternator field circuit and voltage regulator) is isolated from the battery when this switch is open.

706. **Backward Transition Relay - BTS, BTP**

These relays are actuated by the amount of current passing through the main generator leads. As the main generator current increases, due to decreased train speed such as pulling up a heavy grade, the relays are actuated and change the transition one step backward.

707. **Battery Ammeter** (See Art. 223)

This meter is an indication of state of battery. Should read 0 or + as it indicates current flow in or out of battery. Continuous discharge will result in failure.

708. **Battery Charging Contactor** (See Art. 612)

This contactor connects the auxiliary generator to the battery. The reverse current relay closes the battery charging contactor when the auxiliary generator voltage reaches a predetermined setting to charge the battery.

709. **Battery Charging Resistor**

This .05 ohm resistor is connected in series with the auxiliary generator. It prevents excessive battery charging rate when battery is discharged.

710. **Battery Field Contactor**

This contactor closes when the throttle is moved to Run 1 position, connecting the battery to the main generator battery field. During transition from 2 to 3 position and 3 to 2 position, the contactor is opened, reducing the generator output momentarily. This contactor closes when the dynamic brake lever is in "B" and succeeding braking positions while using the dynamic brake.

711. **Battery Field Discharge Resistor**

This resistor shunts the main generator battery field to dissipate the high induced voltage when the circuit to the battery field is opened.

712. **Battery Field Fuse**

Protective 80 ampere fuse in battery field circuit. Located in Low Voltage Panel. If blown, unit will not develop power.

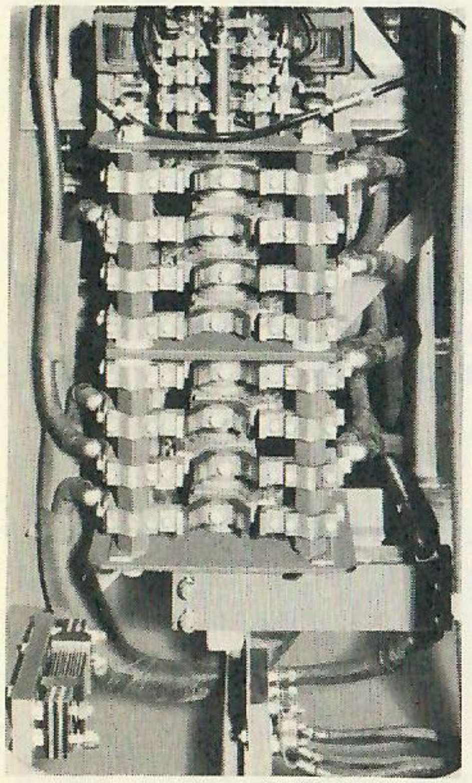
713. **Brake Blower Motors**

The brake blower motors drive blowers which supply air for cooling the dynamic braking grids. There are two brake blower motors in each unit. They operate only when the dynamic brake is being used. In the event of failure of a motor, or blower, the dynamic brake must be cut out on that unit to prevent burning up the grids. For information on "Isolating Engine While Using Dynamic Brake" see Art. 216.

714. **Brake Relay**

This is a double-acting relay, the function of which is to establish the "TOW" position of the cam-switch and partially complete the circuit to the braking contactors when energized.

When de-energized, this relay partially establishes the "Motor" position of the cam-switch and partially completes the circuit to the traction motor contactors.



Cam-Switch
Fig. 7-1

The relay is energized when the transition lever is in "OFF," "B" or succeeding braking positions.

715. **Cab Heater Motors**

A cab heater motor drives the fan behind each cab heater. The 3-speed switches to start, stop, and control the motor speed are located on the panels above the heaters.

716. **Cam-Switch**

This switch is a cam-type, air-operated switch controlled by magnet valves. It has sixteen pairs of main

contacts, a rotary and a cam interlock assembly on top of the cam-switch. When in the "Motor" position, it connects the traction motor armatures in series with their respective fields, and disconnects the braking grids from the motor armatures. When in the "TOW" position, it disconnects the traction motor armatures from their fields, and connects a braking grid across each armature.

717. **Controller (Control Stand)**

The controller (or control stand) contains the throttle lever, reverse lever, and transition lever. The throttle lever, by means of electric contacts, operates the electro-hydraulic governor controls, which control the speed of the Diesel engines through the engine governors. The reverse lever operates electric contacts which close a circuit energizing either the "forward" or "reverse" magnet valves on the reversers in the electrical control cabinets. There is no mechanical connection between the reverse lever and the reverser. The transition lever, through electric contacts, changes the traction motor circuits to obtain the desired locomotive tractive effort and speed. The transition lever when moved to "Off" position and beyond, controls the dynamic braking.

718. **Control Knife Switch**

This switch is located on the distribution panel and controls battery power to the relays, contactors, etc. in the control circuit.

719. **Control Push-Button Switch Box**

For information refer to Art. 120.

720. **Cooling Fans** see Arts. 301 and 641.

721. Defroster Motor

Two motors are used to drive blowers in each cab for windshield defrosting. The motors are operated by a switch located on the control push-button switch box mounted at the right of the engineer.

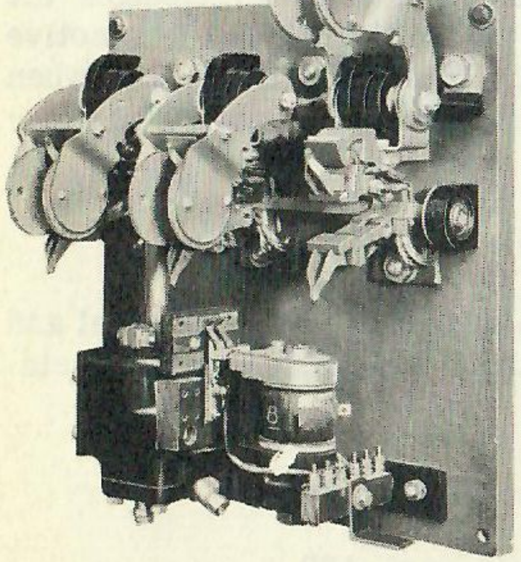
722. Distribution Panel (Art. 120)

723. Dynamic Brake Control Rheostat

The brake control rheostat is located in the bottom of the controller and operates between "B" and maximum braking position of the dynamic brake control lever, to vary the resistance in series with the field loop circuit. This will vary the braking effort of the locomotive.

724. Dynamic Brake Contactors

The dynamic brake contactors connect the four traction motor fields in series with each other and to the main generator during dynamic braking. The braking contactors close when the transition lever is moved to the "Off" position and remain closed when the braking lever is in "B" and succeeding braking positions.



Dynamic Brake Contactors
Fig. 7-2

725. Dynamic Brake Warning Light and Relay

This is a current relay in the dynamic brake circuit. Its current coil is connected in the grid circuit of one traction motor in each unit. The relay contact is set to pull in at 560 amperes and drop out at 540 amperes. A low voltage or bucking coil is provided for setting the relay dropout.

When the relay contact closes, a warning light located on the instrument panel in the cab will light. This indicates that the load on the dynamic brake is excessive and the light will remain on until the load is reduced to the continuous rating of the brake equipment. In some instances the light may light before the triangle is reached if braking in one of the trailing units is heavier than on the lead unit due to variations in engine speed or other factors. See "Dynamic Braking" in Section 6.

726. Engine Room Light Switches

The two (three-way) switches operate independently of each other to turn the engine room lights on or off. If the lights are on, either switch will turn them off, and vice versa.

727. "ER" Relay (See Art. 618).

This relay controls the current supply to the "A," "B" and "C" solenoids of the Electro-Hydraulic governor control. De-energizing this relay will stop the engine if the throttle is in Run 5 or Run 6, or bring the engine to idle in any other throttle position. This relay is inside the engine control and instrument panel.

728. Field Loop Contactor

The field loop contactor is energized when the transition lever is moved to the "Off," "B" and succeeding braking positions. It operates in conjunction with interlocks on top of the cam-switch to place the dynamic brake control rheostat and resistors, and the unit selector switch and its resistors, in series with the field loop circuit.

729. Forward Transition Relay - FTR

This relay is connected directly across the main generator leads in series with two 10,000 ohm resistors and takes full generator voltage. Each time the main generator voltage increases to a predetermined value, due to increased train speed, this relay changes the transition one step forward.

730. Fuel Pump Contactor (See Art. 629).

The fuel pump contactor is located inside the engine control and instrument panel. All fuel pump contactors throughout the locomotive are controlled by the fuel pump master switch on the control push-button switch box. PCS must be reset and PCR energized before the fuel pump contactors can be energized. When the contactor in any unit is closed, the fuel pump can be controlled individually by a toggle-switch mounted on the engine control and instrument panel. Electricity is supplied through this contactor for operating the shutter magnet valves and cooling fan contactors under control of the thermostat switch.

731. Fuel Pump Motor (See Art. 629).

Each engine is equipped with a fuel pump motor rated at 1/4 HP, 1100 RPM. When the master fuel pump control switch on the control push-button switch box in the cab is closed, starting and stopping of the motors can be controlled by a toggle switch mounted on each of the engine control and instrument panels. Operation of the fuel system is covered in Section 5 of this manual.

732. Fuel Pump Switch (Cab)

This is a push-button switch located in the control push-button switch box at the right of the engineer. The fuel pump contactors throughout the locomotive are controlled by this master switch. When this switch is closed, each fuel pump motor can be individually controlled by a toggle-switch located on the engine control and instrument panel.

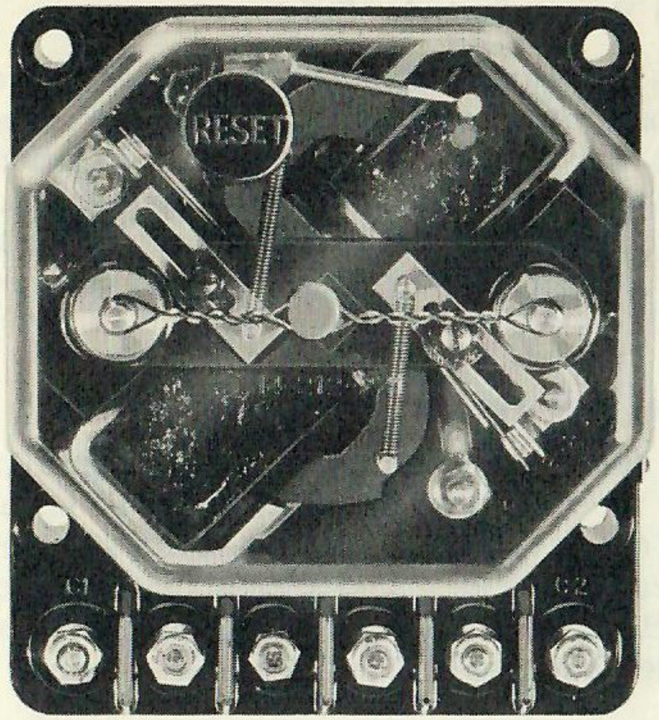
733. Fuse Test Switch

The fuse test switch is located on the distribution panel and is connected in parallel with the fuse test blocks. To test a fuse, turn fuse test switch on to light lamp, place fuse to be tested across fuse test blocks and turn switch off. If lamp goes out, fuse is blown. The lamp socket can also be used to check a lamp.

734. Ground Protective Relay (See Arts. 224, 637).

If a ground occurs in the high voltage system, this relay will open the battery field and main generator shunt field contactors, and by de-energizing the "ER" relay bring the engine to idle except when the throttle is in the 5th or 6th position, and in this event the engines will stop. Should this occur, isolate the engine and reset the relay by pressing in on the reset button on the cover. When the relay is tripped, the white needle will point to the red indicator, and to the yellow indicator when in normal position. If the relay repeatedly opens when the engine speed is increased, the power plant MUST be isolated.

A knife switch in the electrical control cabinet renders the ground protective relay inoperative when opened. This switch is provided for use during certain electrical tests during maintenance operations. It should not be opened on the road except under circumstances



Ground Protective Relay
Fig. 7-3

authorized by definite instructions of the particular railroad on which the locomotive is operating.

A ground in the low voltage system will also trip the relay when an engine is being started. Engines will stop if relay opens when throttle is in 5th or 6th position.

735. **Ground Protective Relay Switch**

This switch opens the circuit to the operating coil of the ground protective relay. See paragraph on "Ground Protective Relay" above.

736. **High Temperature Alarm Switch**

This is a thermal switch located alongside the

engine control and instrument panel, which connects with one thermal element in the water outlet manifold of the engine. If the water temperature exceeds 208° F., this switch closes, lights the hot engine alarm signal light, and energizes the signal relay, which rings the alarm bell. The tube leading from the element to the switch must not be kinked or dented.

737. **Isolation Switch** (See Art. 226)

The isolation switch is located on the engine control and instrument panel. Its purpose is to open and close the control circuit of the unit as occasion demands. When starting the Diesel engine this switch must be in the "START" position. After engine is running, move switch to "RUN" position. This will connect the control circuit of the unit to the engineer's controller. If it becomes necessary to isolate the unit, the isolation switch should be moved to the "START" position. This will bring the engine to idle and cut off the power of this unit. See Subject under "Isolating and Stopping an Engine while Under Power," Art. 216.

738. **Lighting Switch**

The lighting circuits of the locomotive are connected to this double-pole, single-throw switch which is located on the distribution panel of the electrical control cabinet.

739. **Load Indicating Meter** (See Arts. 117, 206).

An ammeter connected to No. 4 traction motor lead gives true amperage through the motor in No. 1 and No. 3 position of transition. In No. 2 and No. 4 position of transition, the readings are not quite accurate due to a small resistance introduced in series with the transition indicator. As M contactor is energized, an interlock opens, inserting this resistance into the circuit to prevent the transition indicator needle from surging, and to give a straight easy reading scale.

740. **Load Regulator and Pilot Valve** (See Arts. 142, 227, and 627).

The load regulator is divided into two sections: the pilot valve which is in the engine governor, and a self-contained unit in a structural steel frame, consisting of an hydraulic vane-type motor attached to a commutator-type rheostat located under the engine control and instrument panel.

741. **Low Oil Pressure and Suction Alarm Switch (LOP, LOS)**

For information, refer to Art. 139.

742. **Main Battery Switch**

This switch isolates all circuits from the battery except the external charging receptacle. The switch should be opened when locomotive is left standing with engines shut down or when charging battery from an external source. This switch is mounted on the Distribution panel.

743. **Main Generator** (See Art. 603).

The main generator is directly connected to the Diesel engine through a flexible coupling. The generator produces direct current for operating the traction motors. A self-aligning bearing in the commutator end housing carries the weight of the commutator end of the generator armature. The other end of the armature is cooled by a blower mounted on the generator and coupled on the end of the auxiliary generator shaft.

744. **No AC Voltage Relay (NVR)**

This relay is in the alternator circuit and should the AC Voltage fail, the alarm bell rings and the "Alternator Failure" warning light (blue light) goes on. The engine speed will return to idle except when the throttle is in the 5th or 6th position, and in this event the engines will be stopped.

A "No AC Voltage" relay is connected across one phase of the AC alternator. At 275 RPM this relay will pick up and will remain energized until voltage drops below a predetermined setting. When it drops out, it will ring the alarm bell in all units, light a blue light in the unit affected, and reduce engine to idle speed. This relay will be de-energized whenever the voltage drops due to failure of the alternator field excitation, which is supplied by the auxiliary generator. The "No AC Voltage" alarm will not operate when the isolation switch is in "START" position.

Since the traction motors are cooled by four AC induction motor blowers, failure of the alternating current will result in burned or badly damaged traction motors if power continues to be applied. The NVR is mounted on the Low Voltage Panel.

745. **Overriding Solenoid**

An overriding cylinder is built into the engine governor. When transition is made 2 to 3 and 3 to 2, the actuating solenoid ORS is energized. This admits high pressure governor oil to the cylinder, raising a piston which raises the load regulator pilot valve 1/8". This causes the load regulator vane motor arm to start toward minimum field, reducing the battery field excitation in the main generator and preventing engine overload at the time transition is made. As the BF contactor closes, ORS is de-energized. A spring brings the load regulator pilot valve back to its normal position and normal operation is resumed.

746. **Parallel Relay (PR)**

This relay is energized when the transition lever is in the No. 3 and No. 4 positions, and operates to close the traction motor parallel (P1, P2, P3 and P4) contactors. It also operates in conjunction with the main generator shunt field and battery field contactors to cause the latter to open during transition from No. 2 to No. 3 position and No. 3 to No. 2 position. On locomotives equipped with automatic transition equipment the parallel relay is somewhat larger than on locomotives with manual transition and incorporates interlocks which change various circuits necessary for automatic transition. The parallel relay is mounted on the low voltage panel.

747. **Pneumatic Control Relay (PCR)**

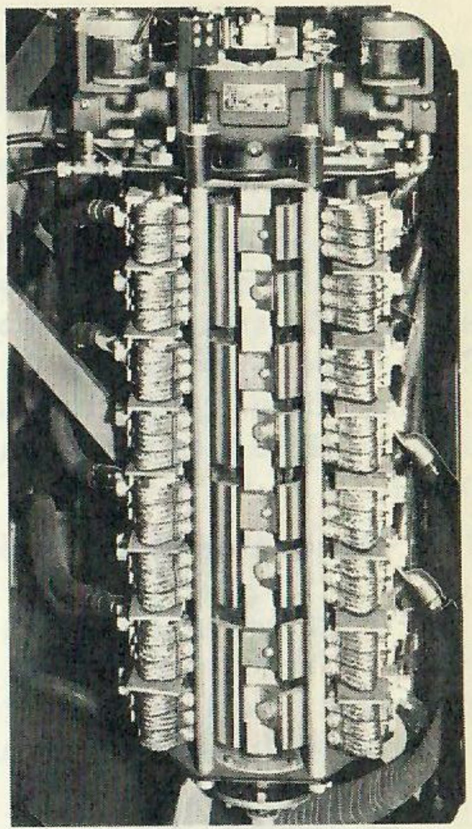
When PCS is reset, either manually or automatically, interlocks close, completing a circuit from the control switch, through closed interlocks with the engine throttle in idle, to energize PCR. PCR will stay energized until PCS trips or the control switch is opened.

748. **Pneumatic Control Switch (PCS)** (See Art. 121).

The purpose of this switch is to reduce the power of the locomotive by bringing the speed of the engines to idle when certain air brake applications take place. The effect of the "PC" switch on the various circuits of the locomotive can be found in the wiring diagrams.

749. **Reverser (RVR)**

The reverser is an air-operated reversing switch. Its purpose is to change the direction of flow of current through the traction motor fields, thus reversing the rotation of the traction motors. The current does not reverse in the main generator. If the control air pressure is low (should be 80 pounds) or either of the magnet valves on top of the reverser is inoperative, the reverser will not operate properly.


Reverser
Fig. 7-4

When the locomotive is to be towed in a train, it is advisable to lock the reverser drum in neutral. During normal operation, a locking pin is screwed into the left-hand side of the reverser. To lock the reverser drum in neutral, this pin should be removed and inserted in the hole on the opposite side. Turn the drum to its neutral position manually and the pin will engage with the hole in the shaft. View of reverser, as shown, in neutral. With the four long segments in full view the reverser is in forward position. With the eight small segments in full view, the reverser is in backward position.

750. **Reverse Current Relay (RCR)**

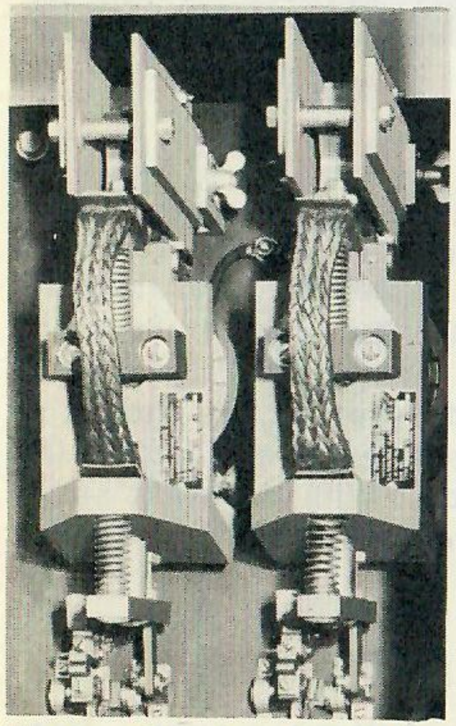
This relay prevents the battery current from "motoring" the auxiliary generator by opening the battery charging contactor when the auxiliary generator voltage drops below the battery voltage.

751. Generator Shunt Field Contactor (SH)

This contactor connects the main generator shunt field to the main generator armature. The generator shunt field contactor is opened during transition from 2 to 3 position and 3 to 2 position thus opening the battery field contactor and reducing the generator output. SH is mounted on the small high voltage control panel.

752. Generator Shunt Field Discharge Resistor

This resistor shunts the main generator shunt field to reduce the high induced voltage when the generator shunt field contactor opens. The resistor is adjacent to the generator shunt field contactor.



Engine Starting Contactors
Fig. 7-5

753. Generator Shunt Field Resistor

This resistor is connected in series with the main generator shunt field. Its purpose is to regulate the shunt field current.

754. Starting Contactors
(See Arts. 221, 617)

The starting contactors (ST- and ST+) are used to connect the battery to the main generator for starting the Diesel engine. These starting contactors are of the magnetic type. There

are two for each power plant which are located in the electrical control cabinet. The starting contactors close when the "START" switch-button is pressed and isolation switch is in "START" position. If either one or both of the starting contactors stick in the closed position when the "START" switch-button is released, the power plant of that unit will not deliver power. (Interlocks on contactors prevent shunt and battery field contactors from closing.)

755. Engine "Start" and "Stop" Switches

These push-button switches are located on the engine control and instrument panel. They will operate only when the isolation switch is in "START" position and control switch, in the control push-button switch box, is closed. The "START" switch operates the starting contactors. The "STOP" switch energizes the "D" magnet valve in the electro-hydraulic governor control stopping the engine.

756. Thermal Overload Relay (See Art. 630). (If used.)

757. Thermostat Switch (See Art. 630).

Engine water temperature control is automatic and is obtained by automatic operation of the shutters and each of the four cooling fans separately.

The automatic temperature control system consists of a thermostat switch with its contact block and fingers, four contactors, two transfer relays, two sets of shutters, and four cooling fans driven by 9 (or 12) HP AC motors.

The thermostat switch with its contact block and fingers is located in the engine water outlet pipe, the control relays and contactors are located in the AC contactor cabinet (electrical control cabinet on early models), and the four cooling fans in the main hatch over the engine. When the engine water discharge temperature reaches 166° F., the shutters on both sides of the unit open automatically. Thereafter, with approximately each 3° F. rise in water temperature, one fan will be started as required until, if necessary, all four fans are running. When the temperature of the cooling water drops, the fans will not cut out one by one, but will remain running until the water temperature drops to 163° F. when all four fans will shut off and the shutters will close simultaneously.

758. Time Delay Relay - TD

This relay prevents transition from progressing to full parallel (#3) at the time transition should change to series-parallel shunt (#2). It is set for a 3 to 4 second delay.

759. Time Delay Backward Relay - TDB

This relay is set for a delay action of from 25 to 30 seconds delay. Its function is to prevent undesired backward transition immediately after a step forward has been made.

760. Traction Motors (TM)

A traction motor drives each pair of wheels on the locomotive through spur gears. The four traction motors under each unit are interconnected through the traction motor control circuit. The traction motors are air cooled by motor driven traction motor blowers, there being one blower for each motor. Serious damage will result if the traction motor blowers become inoperative. The traction motors under one unit of the locomotive are independent of those under any other unit.

761. Traction Motor Field Shunting Resistor

This resistor is connected across the traction motor fields when the traction motor shunt contactors close.

762. Traction Motor Pneumatic Contactors (P1, P2, P3, P4, S14, S23)

These contactors change the traction motor connections from series-parallel to parallel or vice versa. They operate on control air pressure through magnet valves.

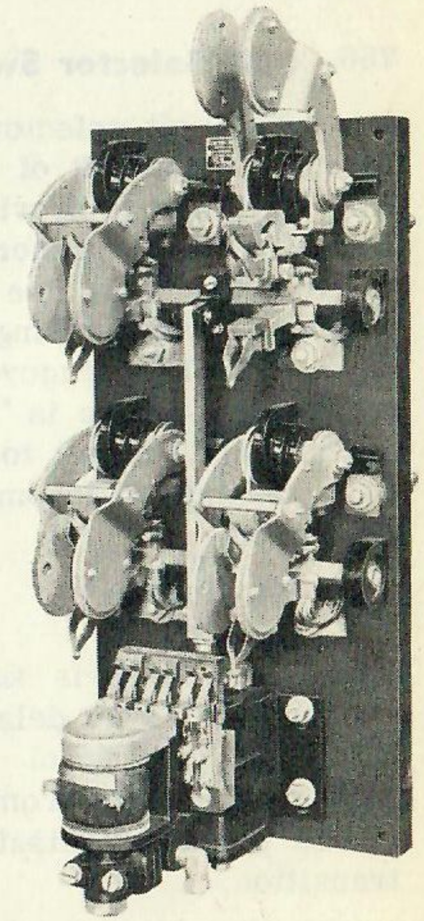
763. Traction Motor Field Shunting Contactors (M)

These contactors connect the shunting resistors across the traction motor fields when transition lever is in No. 2 and No. 4 positions. See Subject under "Traction Motor Field Shunting Resistor" for further description. The contactors are identified by the symbols "M1," "M2," "M3," and "M4" on the schematic diagrams.

764. Transfer Relays

(See Art. 630, Item 3)

There are two of these relays in each unit. One relay controls fan motors Nos.



Traction Motor
Field Shunting Contactor
Fig. 7-6

1 and 4, the other controls fan motors Nos. 2 and 3.

The sequence of operation of the four cooling fans is changed by operation of the four transfer relays. This is provided so that all four fans will get approximately equal work to avoid the probability of the last fan never working. (These relays discontinued Oct. 1, 1947.)

765. **Transition Indicating Meter**(See Art. 737)

Same as load indicating meter. Sometimes called transition and load indicating meter as it serves both purposes.

766. **Unit Selector Switch** (See Art. 129 and 645)

The unit selector switch is a four-position switch located to the left of the engineer's instrument panel. Its purpose is to provide a means of keeping the excitation of the main generator fields at the same relative value while using the dynamic brake, regardless of number of units making up the locomotive. This switch should NEVER be moved when using the dynamic brake, or when an engine is "off the line" or shut down. The switch must be set to correspond with the number of units making up locomotive before leaving the maintenance point.

767. **VT Relay**

This relay is set for 1/2 second delay action. Its function is to delay the opening of S14 and S23 to delay the closing of P1, P4, P2 and P3 contactors during transition from 2 to 3. This delayed action allows partial dissipation of the generator field during transition.

768. **Voltage Regulator**

The voltage regulator maintains the auxiliary

generator voltage at a constant of 74 volts throughout the operating speed range of the engine. This keeps the battery charged and provides a constant source of excitation for the main generator during locomotive operation. A defective voltage regulator may be evidenced by excessive fluctuation of the ammeter in the electrical control cabinet. A defective auxiliary generator will affect the battery charging rate and the excitation of the main generator.

769. **Wheel Slip Relays** (See Art. 636)

There are two wheel slip relays (WSR-1 and WSR-2). Each relay has two normally open contacts. In the event of a pair of wheels slipping, the coil connected to that motor will be energized. One of the contacts will light the wheel slip light and the other will de-energize the main generator shunt field operating coil, thereby dropping out generator shunt field and battery field. Power output will be reduced momentarily until slipping stops.

When wheels slip, it is necessary to reduce the position of the throttle until the wheels stop slipping and then reapply the power by opening the throttle gradually. If necessary to use sand, it should be applied (sparingly) only after the wheels stop slipping.

ELECTRICAL CONTROL CABINET

770. The electrical control cabinet contains most of the electrical control equipment on the locomotive. The cabinet is located directly behind the cab in "A" units and in a comparable position in "B" units. Access to the cabinet is possible from all sides through doors and panels.

On the pages which follow are diagrams and photographs of all equipment contained in the electrical control cabinet. Diagrams on the next page show the external appearance of the cabinet. The panels are alphabetically designated for easy reference to the photographs of each panel.

In addition to the panels of the electrical control cabinet, views showing the equipment in the engine control and instrument panel as well as the AC contactor panel (mounted on the main hatch above the engine control panel) are also included.

Work should never be done on equipment in any of the electrical panels when the unit is operating, as voltages produced by the main generator are dangerous.

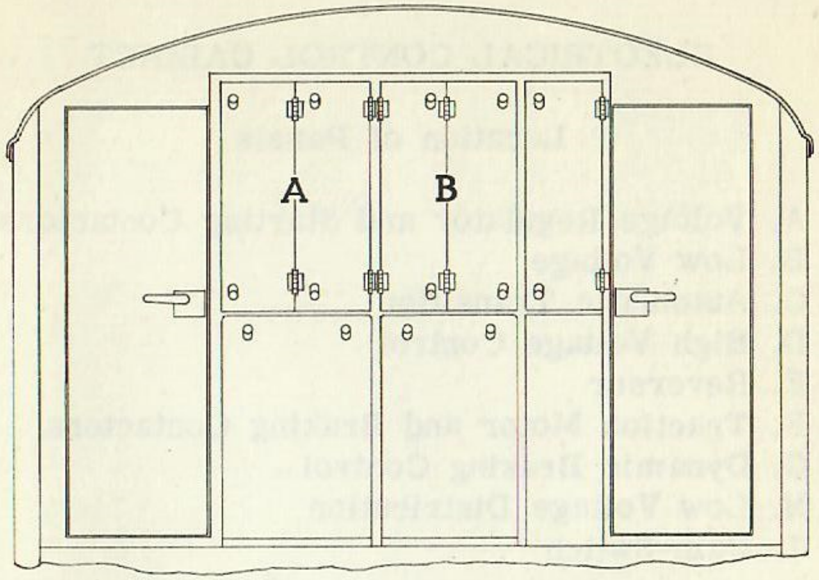


Fig. 7-7a - Cab View

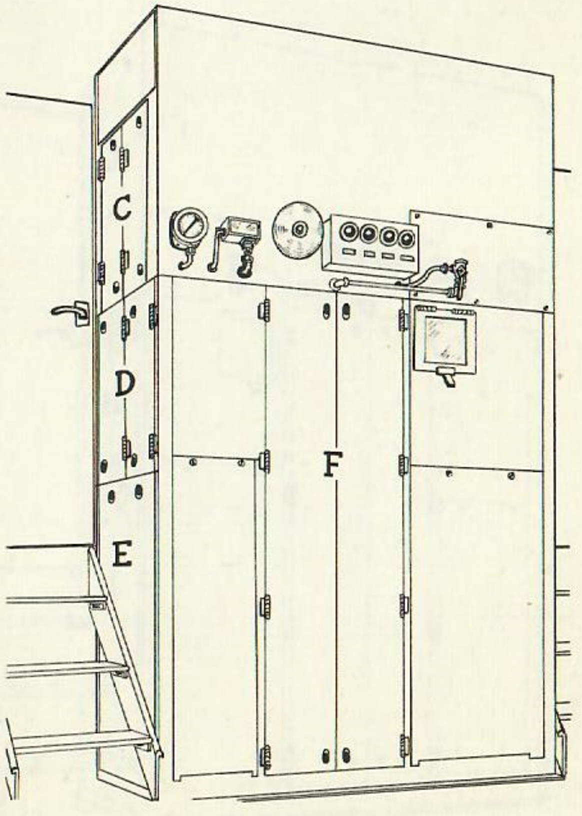


Fig. 7-7b - Engine Room View (Left)

ELECTRICAL CONTROL CABINET

Location of Panels

A. Voltage Regulator and Starting Contactors
B. Low Voltage
C. Automatic Transition
D. High Voltage Control
E. Reverser
F. Traction Motor and Braking Contactors
G. Dynamic Braking Control
H. Low Voltage Distribution
I. Cam-Switch

Detailed views of equipment on each panel are on following pages.

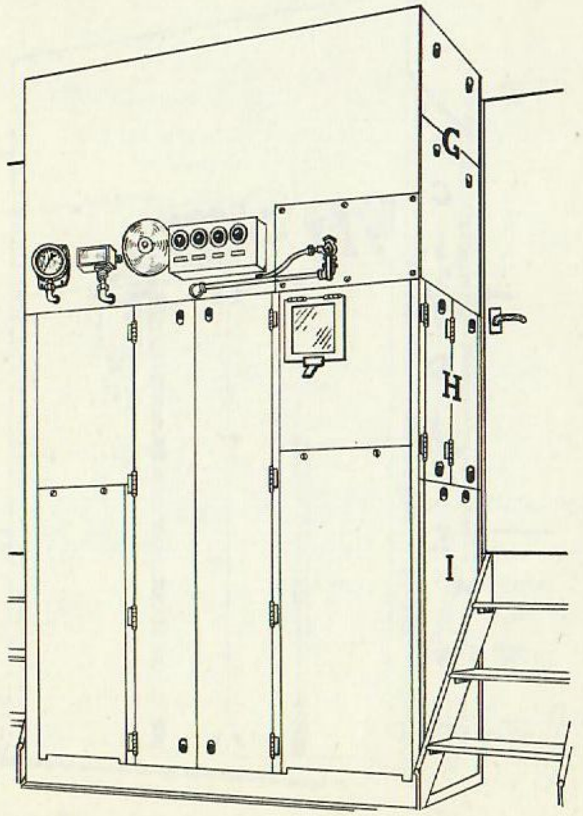
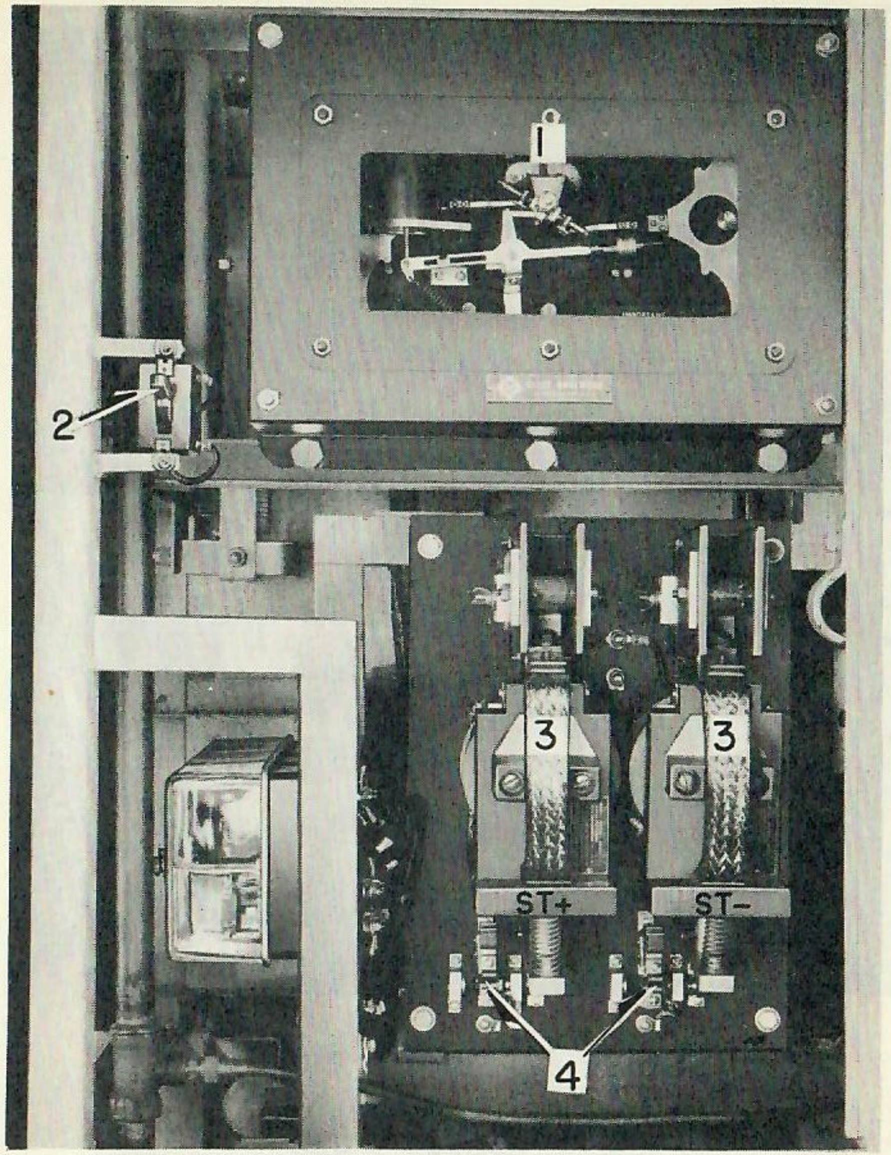
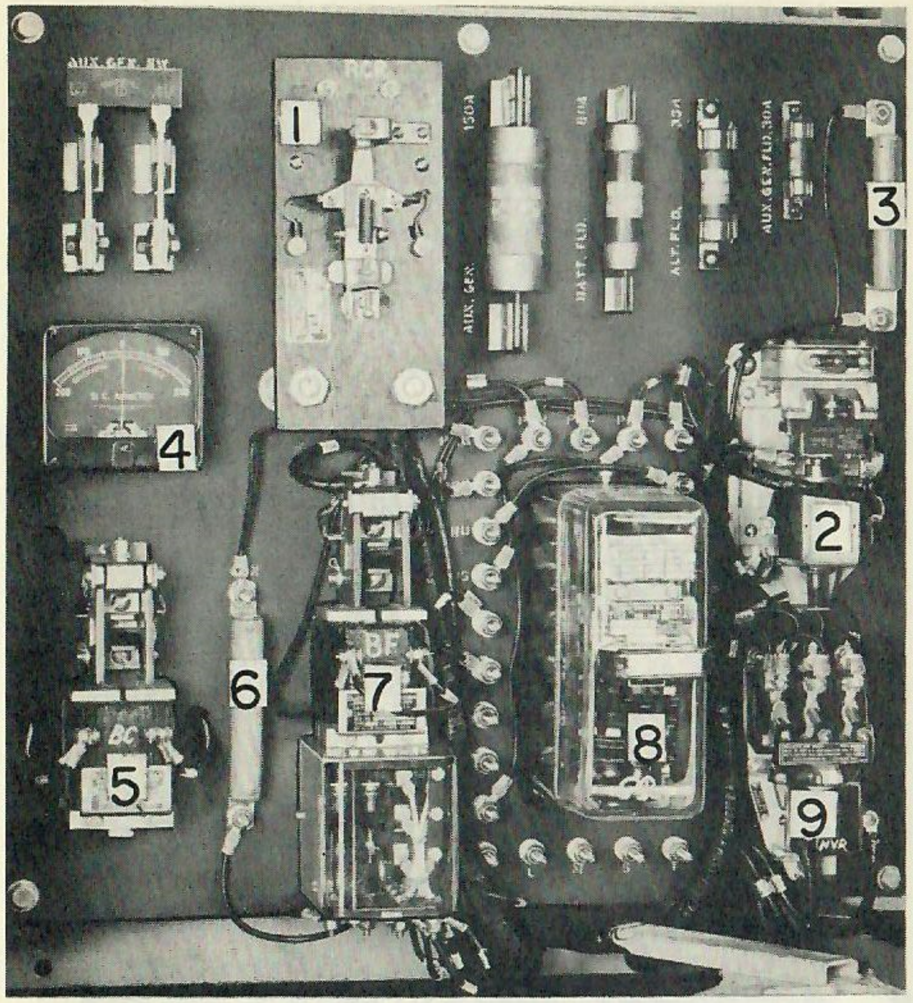


Fig. 7-7c - Engine Room View (Right)



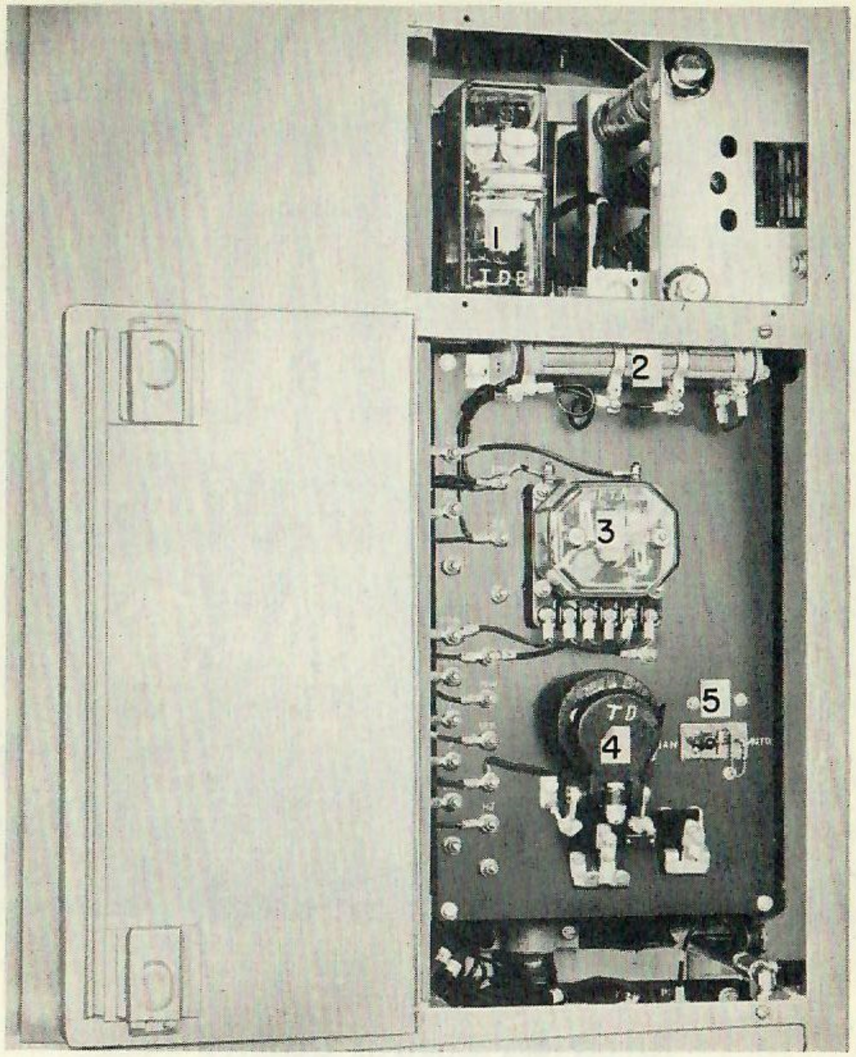
Electrical Control Cabinet
Panel A
Voltage Regulator and Starting Contactor Panels
Fig. 7-8

1. Voltage Regulator
2. Engine Room Light Switch
3. Engine Starting Contactors
4. Starting Contactor Interlocks


AUX.GEN.SW
RCR
1
150A
80A
30A
AUX. GEN.
BATT. FLD.
ALT. FLD.
AUX.GEN.FLD.30A
3
4
2
6
7
BF
8
BC
5
9
NVR

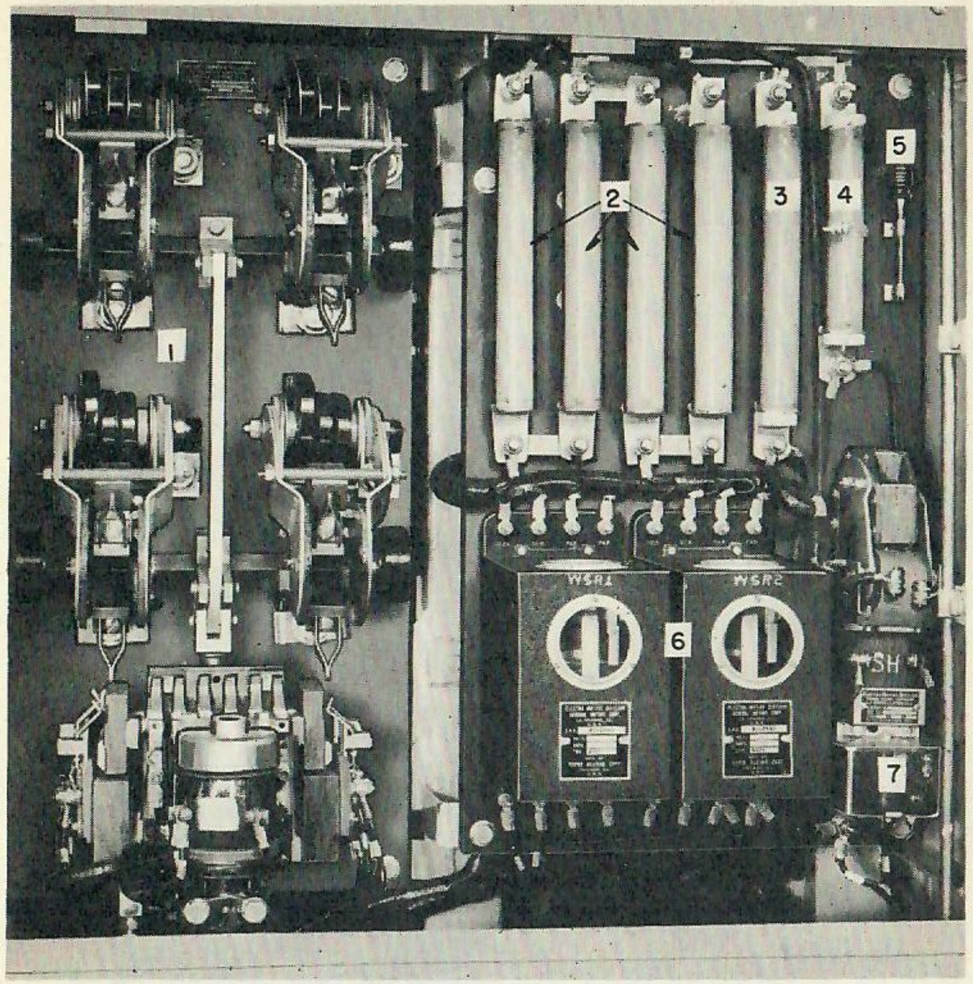
Electrical Control Cabinet
Panel B
Low Voltage Panel
Fig. 7-9

1. Reverse Current Relay (RCR)
2. VT Relay
3. Signal Relay Resistor, 20 ohm
4. Auxiliary Generator Ammeter
5. Battery Charging Contactor (BC)
6. Battery Field Discharge Resistor (4 ohm)
7. Battery Field Contactor (BF)
8. Parallel Relay (Auto. Transition Type) (PR)
9. No Voltage Relay (NVR)


1
TDB
2
3
5
TD
4
MAN
AUTO

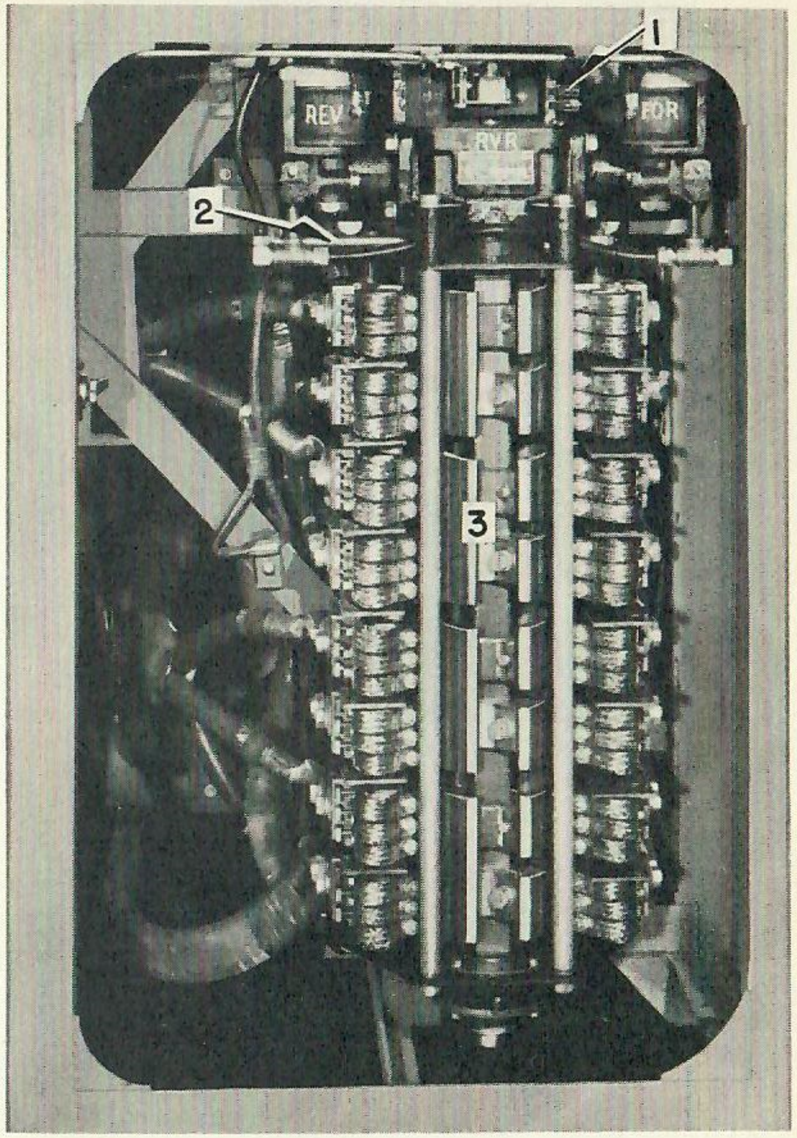
Electrical Control Cabinet
Panel C
Automatic Transition Panel
Fig. 7-10

1. Time Delay Backward Relay (Above Panel)
2. Forward Transition Relay Resistors (Two - 10,000-Ohm)
3. Forward Transition Relay
4. Time Delay Relay
5. MAN-AUTO Selector Switch



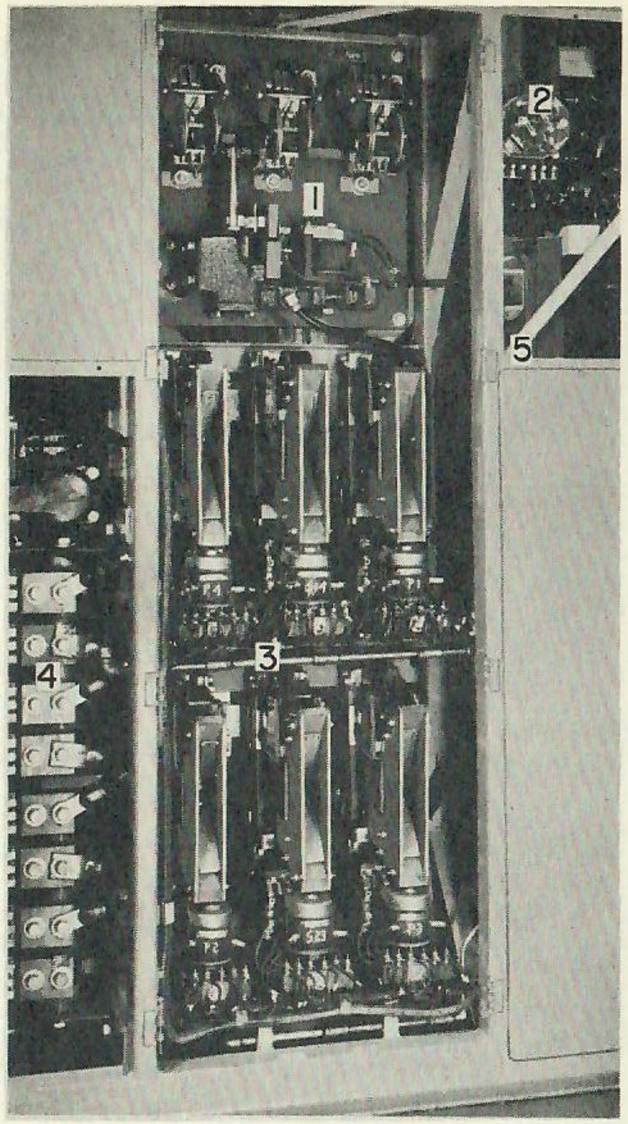
Electrical Control Cabinet
Panel D
High Voltage Control Equipment
Fig. 7-11

1. Traction Motor Field Shunting Contactors (M)
2. 4-2000 Ohm Wheel Slip Relay Resistors
3. 1-400 Ohm Generator Shunt Field Discharge Resistor
4. 35 Ohm Resistor (In SH Operating Coil Circuit)
5. Ground Protective Relay Knife Switch (Sealed)
6. Wheel Slip Relays
7. Generator Shunt Field Contactor



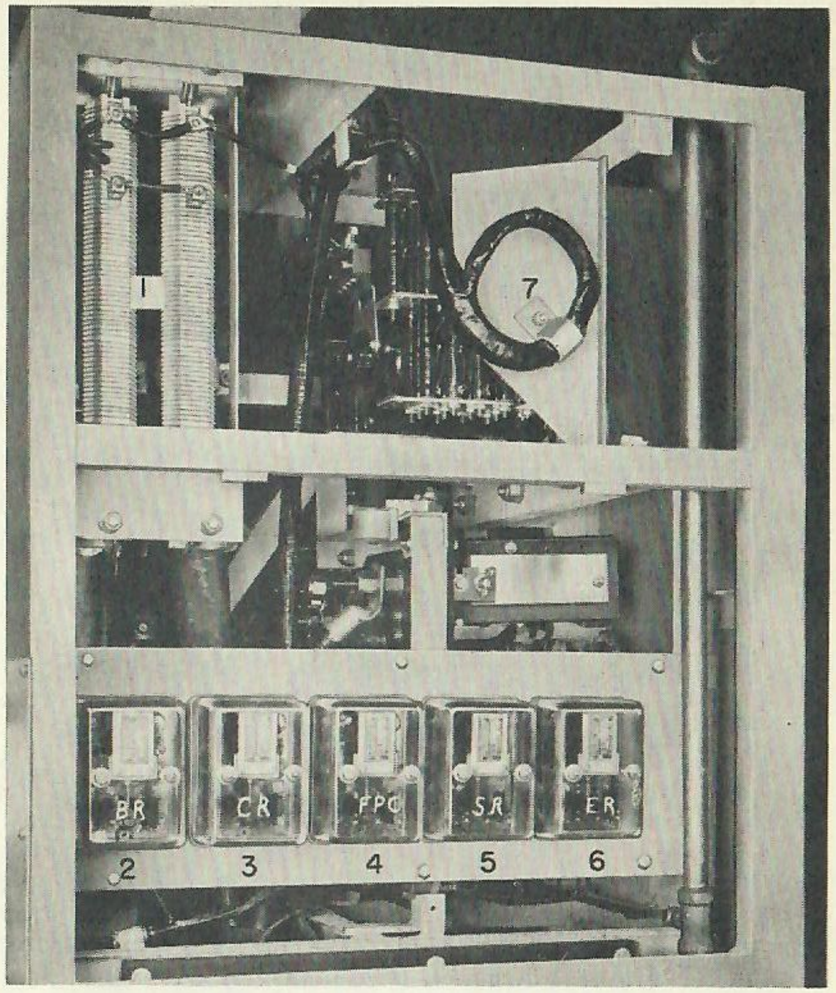
Electrical Control Cabinet
Panel E
Reverser
Fig. 7-12

1. Reverser Interlocks (RVR)
2. Reverser Lock Pin (Unlocked Position)
3. Reverser (Shown in Neutral Position)



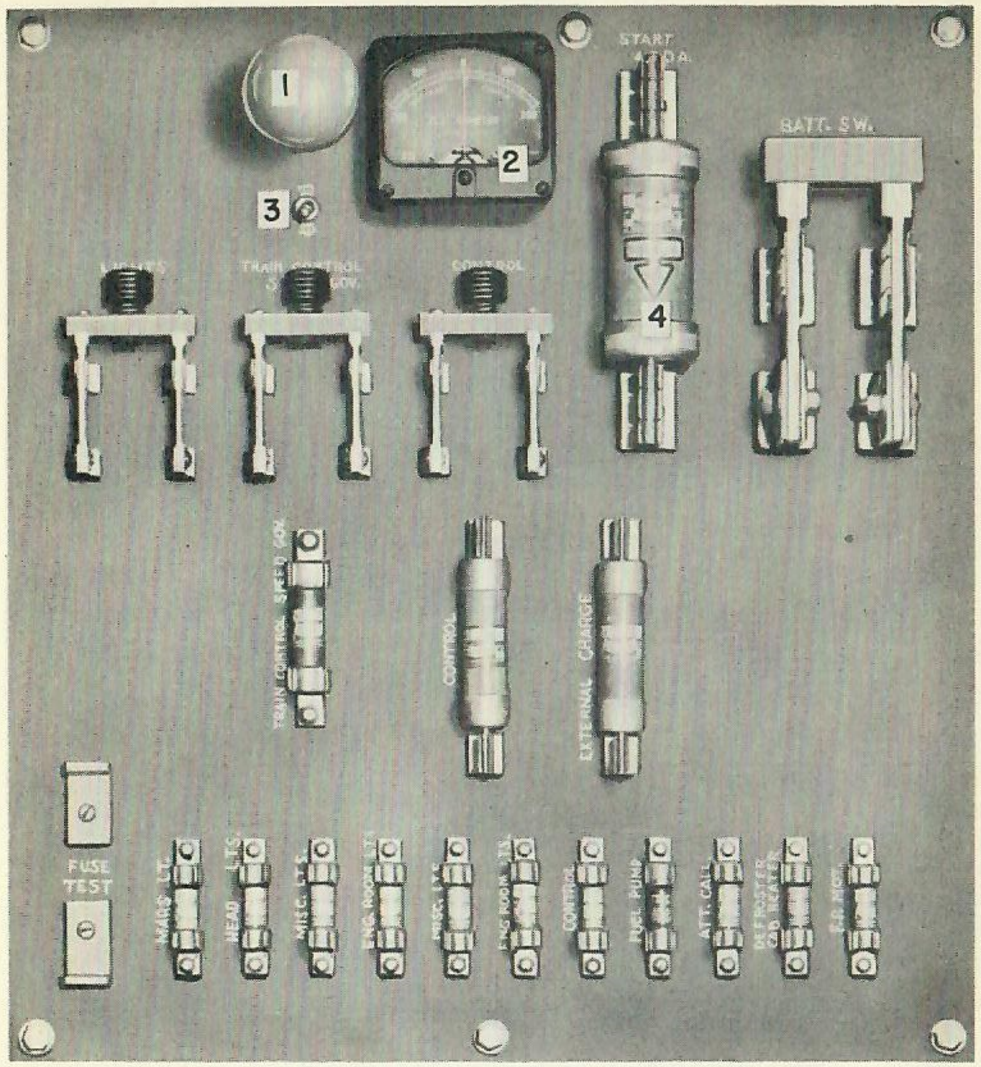
Electrical Control Cabinet
Panel F
Power and Braking Contactors
Fig. 7-13

1. Braking Contactors (B)
2. Ground Protective Relay (GR)
3. Traction Motor Power Contactors (P and S)
4. Reverser (Side View)
5. Brake Warning Relay (BWR)



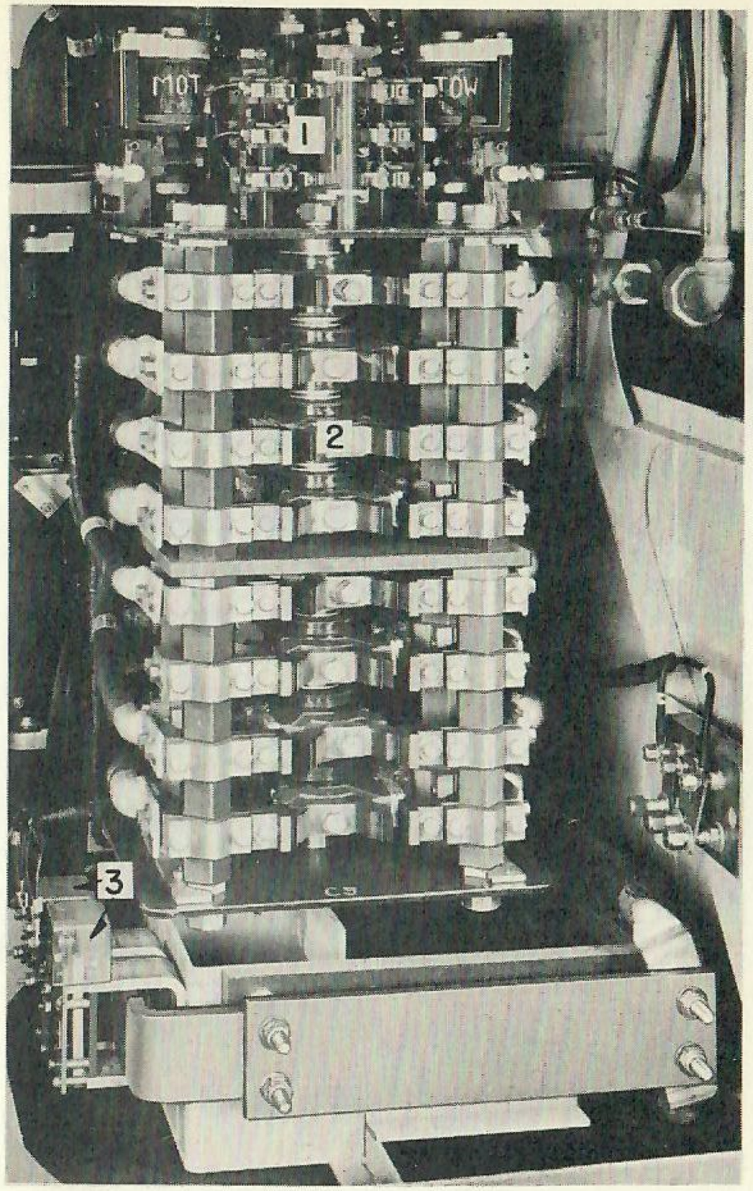
Electrical Control Cabinet
Panel G
Relay Panel
Fig. 7-14

1. Alternator Field Resistor
2. Brake Relay (BR)
3. Air Compressor Relay (CR)
4. Fuel Pump Contactor (FPC)
5. Signal Relay (SR)
6. ER Relay
7. Field Loop Contactor Location -"A"Units Only


1
2
3
4
START 470A
BATT. SW.
LIGHTS
TRAIN CONTROL
CONTROL
TRAIN CONTROL SPEED GOV.
CONTROL
EXTERNAL CHARGE
FUSE TEST
HEAD LTS.
CONTROL
FUEL PUMP
ATT. CALL

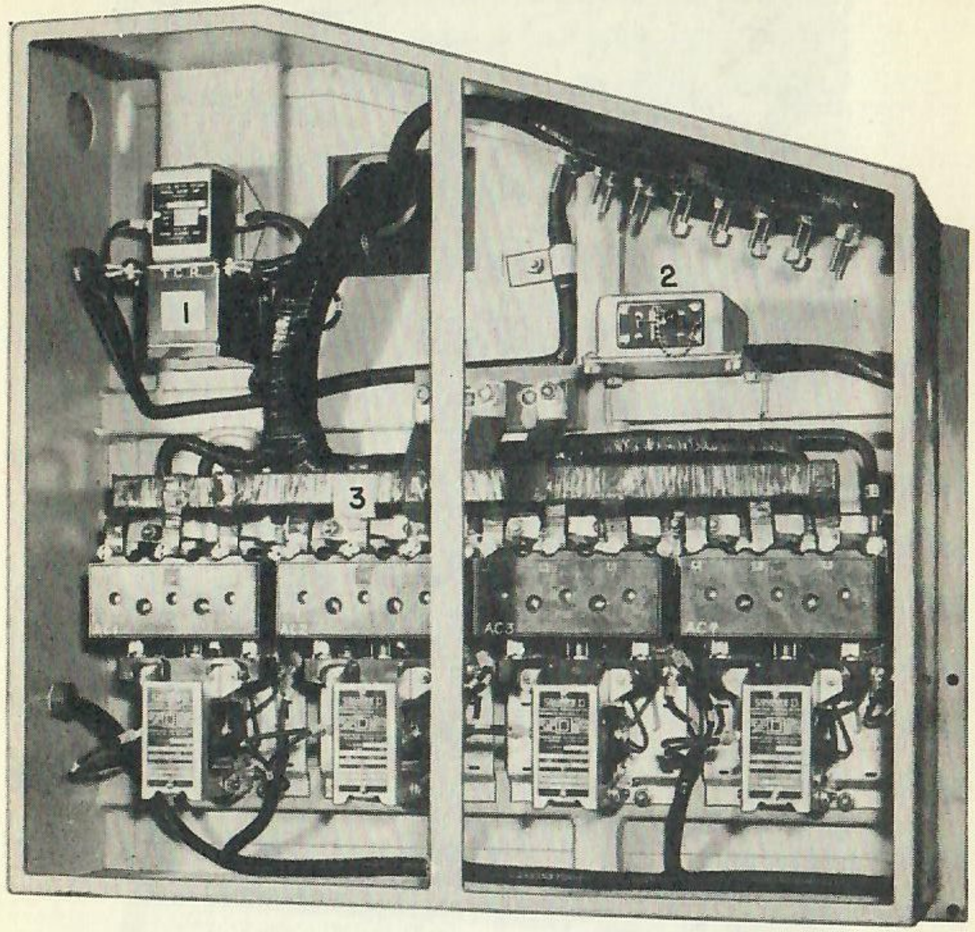
Electrical Control Cabinet
Panel H
Distribution Panel
Fig. 7-15

1. Fuse Test Lamp
2. Battery Ammeter
3. Fuse Test Switch
4. Starting Fuse 400A



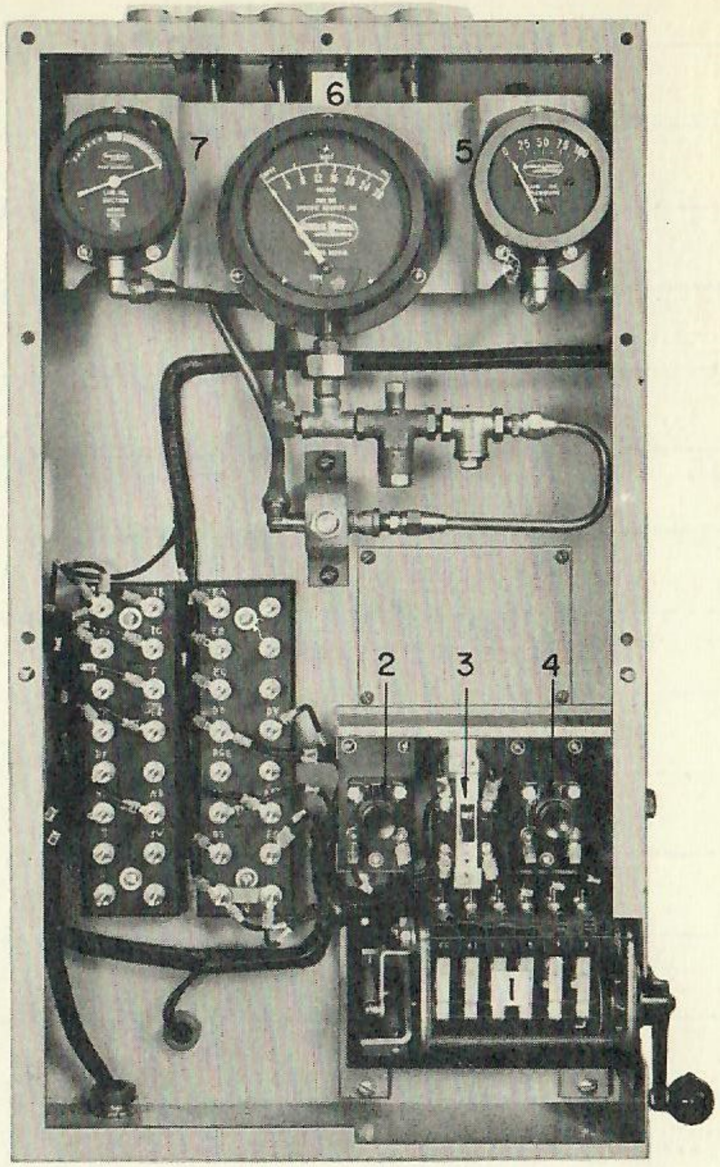
Electrical Control Cabinet
Panel I
Cam-Switch
Fig. 7-16

1. Auxiliary Cam-Switch
2. Cam-Switch
3. Backward Transition Relays - BTS and BTP



AC Contactor Panel
Fig. 7-17

1. Temperature Control Relay
2. Summer-Winter Switch (SWS)
3. AC Motor Contactors



Engine Control and Instrument Panel
Fig. 7-18

1. Isolation Switch
2. Engine "Stop" Button
3. Fuel Pump Motor Switch
4. Engine "Start" Button
5. Lube Oil Pressure Gauge
6. Fuel Oil Gauge (Tank Level)
7. Lube Oil Suction Gauge

NOTES

SECTION 8
AIR SYSTEM

800. **Air Compressor**

Each power plant in the locomotive is equipped with a Gardner-Denver type WXE three-cylinder air compressor, rated at 178 cubic feet of air per minute at 800 RPM. It is driven by the shaft of the main generator through a flexible coupling. The compressor has its own oil pump and pressure lubricating system. Oil level in the crankcase can be checked on the bayonet type gauge. Lubricating oil pressure should be from 12 to 15 pounds at 800 RPM and not less than 5 pounds at idle (hot oil). Since each air compressor is directly connected to an engine and in operation at all times when the engine is running, an unloader is provided in the heads of both high and low pressure cylinders which cuts out the compressing action when actuated by air pressure. The unloader accomplishes this by blocking open the suction or intake valves of the high and low pressure cylinders. When the air operating the unloader is cut off, the unloader releases the suction valves and the compressor resumes pumping. Control air actuates the unloader valves.

The compressor consists of two low pressure cylinders and one high pressure cylinder. The pistons of all three cylinders are driven by a common crankshaft. The two low pressure cylinders are set at an angle to the vertical high pressure cylinder. Air from the low pressure cylinder goes to an intercooler, or radiator, to be cooled before entering the high pressure cylinder. The intercooler is provided with a pressure gauge and safety valve. The gauge normally reads approximately 32 pounds when the compressor is loaded. The intercooler safety valve is set for 50 pounds. Any marked deviation of intercooler pressure from 32 pounds should be reported to maintenance for attention.

Condensation and oil collects in the sump of the bottom header of the compressor intercooler and should be drained once at each crew change and at the regular maintenance period. A drain valve is provided in each sump for this purpose. Operate the intercooler safety valve by hand, when draining intercooler, to be certain that it functions properly.

The compressor control switch in each unit is actuated by main reservoir pressure.

The compressor control circuit in turn energizes a magnet valve admitting control air to the unloader valves unloading the compressor. De-energizing the control circuit releases the unloaders and causes the compressor to resume pumping.

Failure of the compressor control circuit or failure of the control air supply will result in continuous pumping by the compressors, to insure an air supply at all times.

The operation of the compressor control circuit is described in Art. 631.

801. General

From the high pressure cylinder of the compressor, the air passes through an oil separator to the aftercooler assembly. It then passes through the aftercooler discharge filter to the No. 1 main reservoir under the carbody. The change of air pressure in No. 1 main reservoir forces the condensation into a second sump located inside the carbody. This sump is provided with a drain valve. The air flow from the No. 1 main reservoir passes through a check valve into the No. 2 main reservoir, under the cab floor in the "A" unit. From the outlet of the second main reservoir, the air passes through an H-type filter to the air brake system and the electrical control air system. Compressed air for operation of the windshield wipers, horns and bell ringer is taken from the line between the two main reservoirs on the No. 1 reservoir side of the check valve in the "A" unit. See Chart X in the Appendix.

802. Electrical Control Air System

Air pressure is used to operate the various electro-pneumatic contactors, reversers, and cam-switches in the locomotive. In each unit, compressed air for these purposes is drawn from the discharge line of the No. 2 main reservoir and passes through an air regulator which reduces the pressure to 80 pounds. The control air passes through a filter to the control air reservoir. From the reservoir the air flows to the electrical control cabinet. The air passes through a strainer located near the control panel which collects dirt and moisture remaining in the air.

In the electrical control cabinet, the air pressure operates:

1. Reverser
2. P1, P2, P3 and P4 parallel contactors.
3. S14 and S23 series contactors.
4. Motor shunting contactor.
5. Cam-switch and braking contactors (on dynamic brake equipped locomotives only).

Control air also actuates air compressor unloader valves.

803. Draining of Air System

The air system should be drained periodically to prevent moisture from being carried into the air brake and electric control air systems. The frequency of draining will depend on local conditions and can be determined by practice. It is recommended that draining be done at the time of each crew change, until a definite schedule can be determined by the individual railroad.

The elements of the equipment to be drained are:

1. Air compressor oil separator.
2. Upper sump reservoir.
3. Lower sump reservoir.
4. No. 2 main reservoir under cab floor.
5. Type H filter.
6. Electrical control air regulator.
7. Electrical control air reservoir.
8. Strainers at engine control and instrument panel and electrical control cabinet.
9. Air compressor intercooler.

804. **Electrical Control Air Pressure**

Control air pressure is maintained at 80 pounds, plus or minus 3 pounds, by a pressure regulator in each unit. The control air pressure gauge is mounted on the distribution panel in the electrical control cabinet.

If the control air pressure gauge should indicate main reservoir pressure, the regulator valve is probably stuck. Open the drain at the bottom of the regulator. If this does not remedy the condition, a report should be made to maintenance for correction. The main reservoir air pressure in the electrical air system will not cause any serious difficulties for the remainder of the trip.

805. **Sanding** (See Arts. 127, 151 and 764)

The sanders are operated manually by depressing the sanding bail on the automatic brake valves. The sanders will also operate automatically if an emergency air brake application is made. In some cases railroads have specified that the sanding feature in the automatic brake valve be omitted and a single-acting independent sanding valve be installed.

The sand capacity is four cubic feet in each sand box. This gives a total capacity of 16 cubic feet in each unit.

806. **Windshield Wipers**

The speed of the wiper is controlled by the needle valve which turns the wiper on and off. Do not run the wiper on a dry window as dirt on the glass or blade will scratch the glass. The wiper blade should be replaced when the rubber becomes worn or hard.

807. **Bell and Ringer**

The 12-inch bell, located behind the pilot of the "A" unit, is operated by a remote controlled air type bell-ringer. The bell operating valve is located at the engineer's control station.

808. **Air Brake System** (See Art. 122)

Refer to instruction pamphlet supplied by the Westinghouse Air Brake Company for instructions on the operation of the air brake equipment. This air brake pamphlet includes piping diagrams and sectional drawings.

NOTES

SECTION 9

TRUCKS AND MISCELLANEOUS EQUIPMENT

900. Coupler Arrangement

At the No. 1 end of each "A" unit there are type "E" couplers. Couplers or links are provided between the "A" and "B" units depending on the specifications of the railroad. At the No. 2 end of each "B" unit, there are type "E" couplers.

901. Removing Wheels

Jacking pads are provided on the body of the locomotive (See Chart XI) for the purpose of removing the weight of the locomotive from the truck prior to dropping any one of the pairs of wheels, and under no circumstances should any of the pairs of wheels be dropped from the truck without first supporting the weight of the locomotive on these jacking pads.

If these instructions are not closely followed, serious damage may result to the carbody and trucks of the locomotive.

902. Removing Trucks

Chart XI shows the various jacking pads, blocking pads and their locations, as well as the lift required so the trucks may be removed sideways.

903. General

If a drop table is not available and a truck is to be removed from one end, the other end must also be raised at least halfway out of the center plate pocket, or 2 inches;

otherwise the center plate pocket will be sprung out of shape or cracked.

In cases where an overhead crane is not available and jacks are used for lifting, care must be exercised that jacks on opposite sides of the locomotive are raised equal amounts; otherwise the carbody may be sprung out of shape. Jacking height may be saved by blocking solid between the underside of the journal boxes and the pedestal tie bars, keeping the coil springs compressed. Additional height may be saved by blocking or clamping the elliptical springs. Blocking should be done before removing any weight off the trucks.

Hoisting levers may require some reworking for individual locomotives and should be carried on the particular locomotive for which they have been fitted.

Blocking should always be provided if carbody is to be held in raised position for any length of time.

Two jacking pads are provided for each end of the locomotive, as indicated on Chart XI. Jacking should always be done on these jacking pads.

Carbody and truck locking plates are removed from underneath carbody and are located at each side bearing.

904. **Emergency**

In case of a wreck, a locomotive may be lifted by the coupler shank, providing a new coupler is at hand and proper blocking is provided between the top and sides of coupler shank and coupler pocket. While Electro-Motive cannot be responsible for possible damage or breakage of parts by lifting in this manner, it has been done on several occasions without damage but should only be done in extreme emergencies with the railroad taking all the responsibility.

Truck and carbody locking plates on all locomotives have sufficient strength to lift the trucks with the carbody.

If trucks are to be lifted with the carbody, springs should be blocked, as this will save approximately 3 inches of jacking. Blocking can also be placed between each journal box and pedestal tie bar to further reduce the lift.

905. **Journal Boxes (Hyatt)**

All of the journal boxes are similar internally but vary externally according to whether they are plain boxes or have a speed recorder connection. The speed recorder connection is mounted on the No. 1 axle journal box of the No. 1 truck at the left-hand side of the locomotive.

Each journal box is equipped with a "stench bomb." This device consists of a cylindrical container holding a liquid which, when heated, gives off an extremely pungent and penetrating odor. The container is sealed with a bismuth solder plug. If for any reason the temperature inside the journal box exceeds 220° F., the plug melts, instantly releasing the stench agent to the atmosphere.

When the resultant odor is detected by the locomotive or train crews, the train should be stopped at once and the overheated bearing located.

An examination should then be made to determine the cause of the overheating and proper precautions taken before operating the equipment further. When the equipment reaches the shop, all parts of the bearing and journal box should be thoroughly examined, any necessary repairs made, and a new "stench bomb" applied.

NOTES

SECTION 10

STEAM GENERATOR
OK-4630 OK-4616

INTRODUCTION

The instructions contained in this section are for the guidance of personnel engaged in the operation of OK series steam generators. A general description of the steam generator is given, the operating technique is outlined and a trouble shooting section is provided for the operator.

The symbol number after each device mentioned in the text refers to the piping schematic chart, Fig. 10-9. The numbers are used to facilitate identification of the various devices.

The chart shows the various controls and devices on the OK series of steam generators and outlines the flow of fuel, water and steam.

DESCRIPTION

Steam generators of the 4630 series have a rated capacity of 3000 pounds of water evaporation per hour; 4616 steam generators have a rated evaporative capacity of 1600 pounds per hour. Operation is completely automatic after the steam generator is started, and full operating steam pressure is reached within a few minutes.

The steam generating part of the unit consists of three sets of coiled water tubing, nested and connected in series to form a single tube several hundred feet long. Water is pumped into the coil inlet and con-

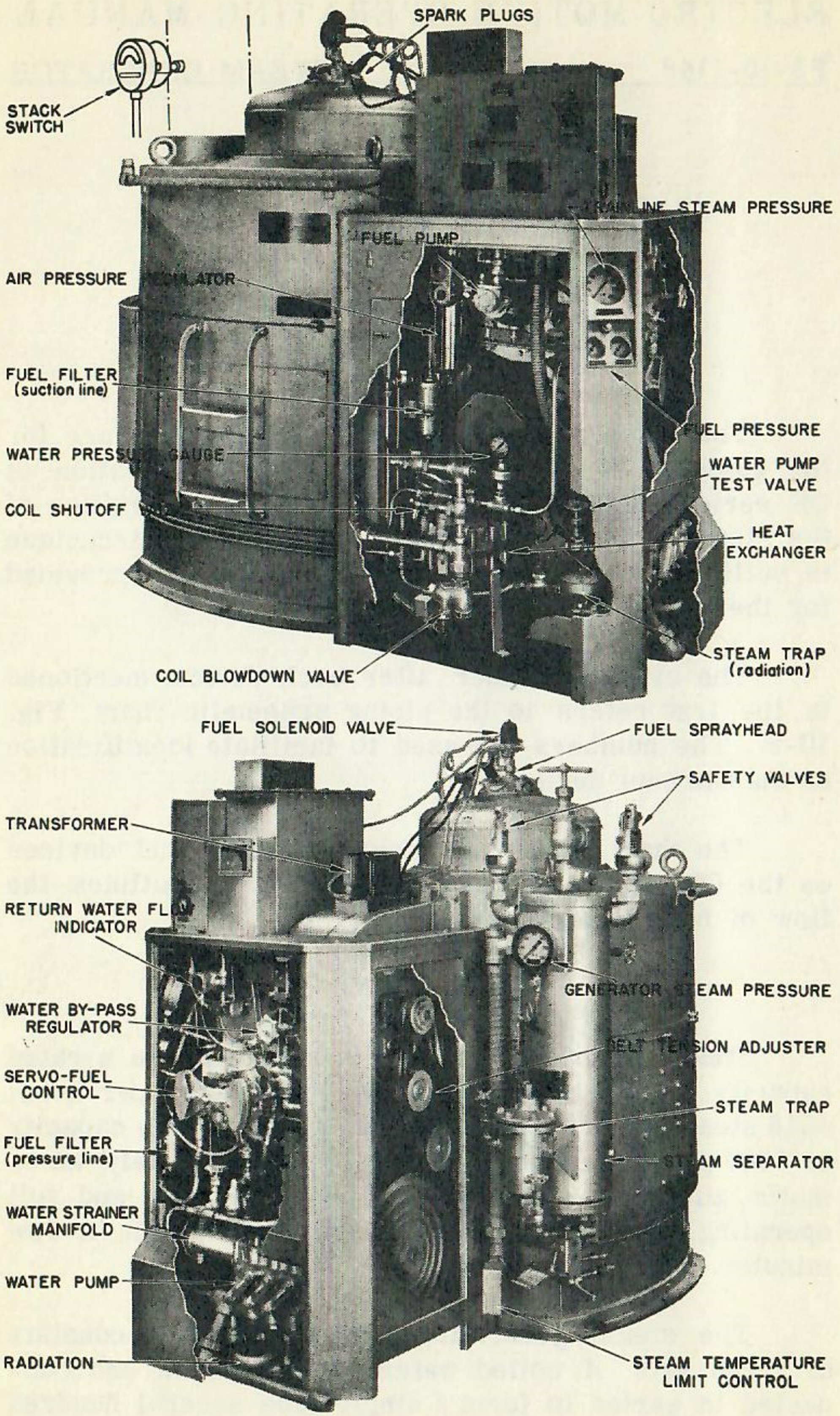

SPARK PLUGS
STACK SWITCH
TRAINLINE STEAM PRESSURE
FUEL PUMP
AIR PRESSURE REGULATOR
FUEL FILTER (suction line)
FUEL PRESSURE
WATER PRESSURE GAUGE
WATER PUMP TEST VALVE
COIL SHUTOFF
HEAT EXCHANGER
STEAM TRAP (radiation)
COIL BLOWDOWN VALVE
FUEL SOLENOID VALVE
FUEL SPRAYHEAD
SAFETY VALVES
TRANSFORMER
RETURN WATER FLOW INDICATOR
GENERATOR STEAM PRESSURE
WATER BY-PASS REGULATOR
BELT TENSION ADJUSTER
SERVO-FUEL CONTROL
STEAM TRAP
FUEL FILTER (pressure line)
STEAM SEPARATOR
WATER STRAINER MANIFOLD
WATER PUMP
RADIATION
STEAM TEMPERATURE LIMIT CONTROL

Fig. 10-1 - OK-4630 Vapor-Clarkson Steam Generator

verted to steam as it progresses through the coils. Heat is furnished by the combustion of diesel fuel oil, which is sprayed by compressed air through the atomizing nozzle in the fuel spray head-105 into the firepot above the coils. Here the fine oil spray mixes with air supplied by the blower-202, and is ignited by a continuous electric spark-220. The fire and hot gases flow, first downward, then outward through the nest of coils.

The supply of fuel is regulated to evaporate 90% to 95% of the water pumped through the coils. The excess water flushes scale and sludge from the coils and is carried over with the steam into the steam separator-221, where the water and sludge are removed before the steam flows into the trainline.

The excess water collects in the bottom of the steam separator. Water above the level of the return outlet flows out through a steam trap-223 and through the heat exchanger-213, where it gives up its heat to the incoming feed water. From the heat exchanger the return water flows back to the water supply tank-232.

The motor converter-215 drives the blower-202, water pump-230 and fuel pump-209 at a constant speed. The water by-pass regulator-111 automatically controls the steam generator output by regulating the amount of water fed to the coils. Before entering the coils, the water passes through the servo-fuel control-108, which admits fuel to the spray nozzle in direct proportion to the amount of water entering the coils. The servo-fuel control also adjusts the damper-203 to admit the proper amount of air for efficient combustion of the fuel.

The trainline steam pressure is regulated by adjusting the handwheel on the water by-pass regulator-111. The length of train and the weather conditions determine the setting.

BEFORE STARTING

On OK models, the valves designated by odd numbers must be OPEN during normal operation of the steam generator. Valves designated by even numvers must be CLOSED during normal operation of the steam generator. Normally open valves are fitted with a cross type handle; normally closed valves are fitted with the standard round handle.

1. Make certain that the following valves are OPEN:

   Atomizing Air Shutoff Valve-1
   Coil Shutoff Valve-3
   Return Water Outlet Valve-9
   Steam Admission Valve-11 to Trainline Pressure Gauge-224
   Steam Admission Valve-13 to Water By-Pass Regulator-111
   Three-Way Washout Valve-17
   Water By-Pass Regulator Shutoff Valve-19
   Water Supply Stop Valve-21

2. Be sure that the following valves are CLOSED:

   Coil Blowdown Valve-2
   Layover Connection Shutoff Valve-6
   Manual Water By-Pass Valve-8
   Steam Admission Valve-10 to Radiation-217
   Washout Inlet Valves-14 and 16
   Water Pump Test Valve-18
   Water Drain Valves-20 and 22

3. See that both the overload reset button-106 and the stack switch-109 reset button are "in." The overload reset button is located inside the control panel on the magnetic overload relay.

TO FILL

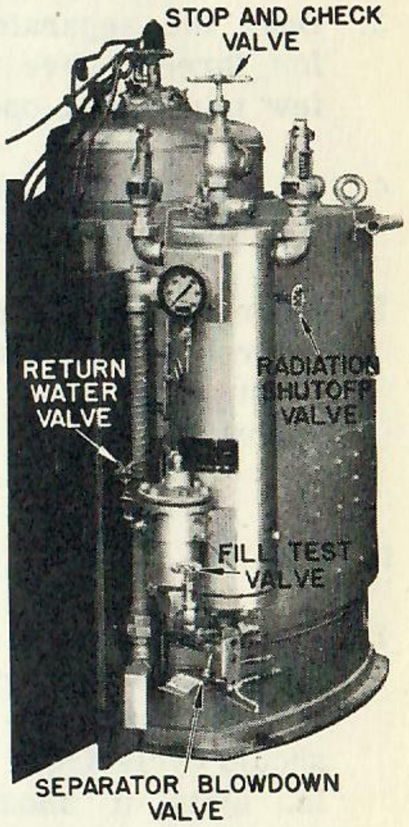
1. Open the atomizing air shutoff valve-1 and fill-test valve-4; latch open the separator blowdown valve-12 to drain the steam separator. Close the separator blowdown valve when the separator is completely drained.

2. Close the main switch and turn the control switch-102 to FILL.

3. While the coils are filling see that spark-220 is available for ignition. Check ALL valves.

4. When water discharges from the fill-test valve-4 turn the control switch-102 to OFF and close the fill-test valve.

NOTE: If the coils are empty it will take about five minutes to fill the steam generator with water.



Steam Separator on OK-4630
Fig. 10-2

TO START

CAUTION: Do not start the steam generator unless the coils are filled.

1. Latch open the separator blowdown valve-12 and turn the control switch-102 to RUN. (For easy starting, be sure the control switch has been OFF

long enough for the motor to come to a full stop.)

2. Close the separator blowdown valve when the generator steam pressure gauge-212 registers 50 lbs.

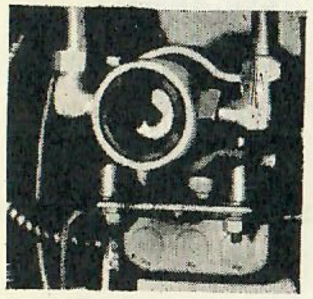
3. Open the separator blowdown valve several times for three to five second intervals during the first few minutes of operation.

4. Set the water by-pass regulator-111 to the required trainline pressure.

5. After the trainline is coupled, open the remote control trainline shutoff valve-7 by depressing the reset lever-7a. Then open the stop and check valve-15.

NOTES:

1. Check the return water flow after the steam generator has settled down to a steady output. On 3000 lb. units the return water flow indicator-218 should cycle from 4 to 12 times a minute; on 1600 lb. units it should cycle from 4 to 8 times a minute.



Return Water
Flow Indicator
Fig. 10-3

2. If the steam generator does not start or function properly, check all valves to see that they are open or closed as indicated in Fig. 10-9.

3. The steam generator should come up to full operating pressure in one or two minutes; it may take 10 or 15 minutes to build up the required operating steam pressure in the trainline.

RUNNING ATTENTION

1. Open the separator blowdown valve-12 for five seconds at least once every hour.

2. Turn the handle on the fuel filter-206 during stops. At the same time, turn the handle on the treatment injector filter-225, where this method of water treatment is used.

TO SHUT DOWN THE STEAM GENERATOR

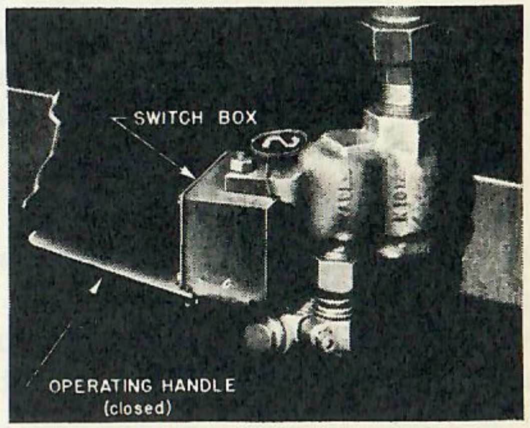
For short stops it is only necessary to close the stop and check valve-15. The fire will cycle and maintain operating pressure in the steam generator. For terminal stops, proceed as follows:

1. Close the stop and check valve-15 and the remote control trainline shutoff valve-7.

2. Set the water by-pass regulator-111 to maximum output. When the generator steam pressure gauge-212 registers 200 lbs. turn the control switch-102 to OFF.

3. Open the coil blowdown valve-2. When the generator pressure drops to 75 lbs. close the valve.

4. Open the separator blowdown valve-12 and blow down the steam separator-221 with the remaining pressure. Close the separator blowdown valve.



Coil Blowdown Valve
OK-4630
Fig. 10-4

5. Fill the coils with water.

6. Close the atomizing air shutoff valve-1 and open the main switch.

NOTE: When starting, do not omit draining the steam separator, opening the fill-test valve, and again filling the steam generator with water. If the coils are already full, it will only take a moment for water to discharge from the fill-test valve.

FREEZING WEATHER PRECAUTIONS

The inlet valve-10 to the radiation-217 should be opened when operating during severe weather.

If a locomotive with a multiple installation does not have all of its steam generators in operation, open the coil blowdown valve-2, the layover connection shutoff valve-6 and the inlet valve-10 to the radiation on idle steam generators.

CAUTION: Layover connection shutoff valve-6 must be closed when trainline shutoff valve-7 is closed to cut a car out of a train.

If a locomotive is left standing out of service, operate one of the steam generators or make a connection to the yard steam line. In extremely cold weather the water pump-230 and steam generator controls should be given additional protection against freezing.

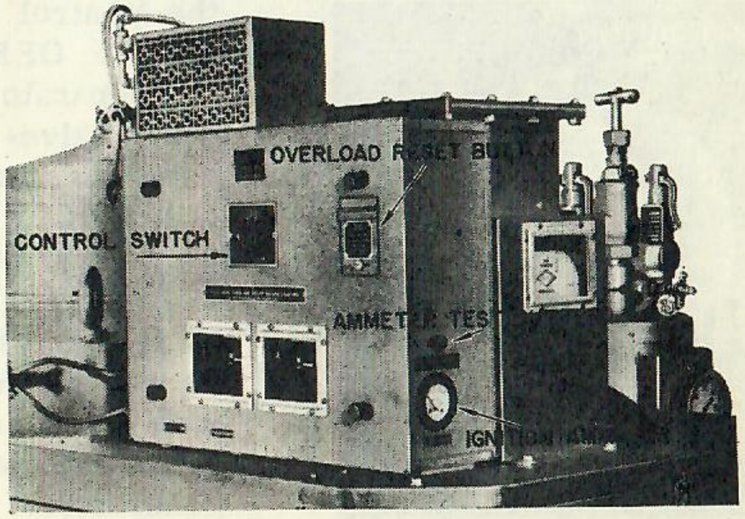
If no steam at all is available, thoroughly drain the steam generator. Open the drain valves-20 and 22,

the water pump test valve-18, the coil blowdown valve-2, the separator blowdown valve-12 and the coil shutoff valve-3. Break the pipe connections where necessary to completely drain the piping. Turn the water pump by hand to clear it of water, or blow it out with compressed air. Remove the cover of the water treatment or water strainer tank-234 and make sure it is drained.

TROUBLE SHOOTING

If one of the protective switches (magnetic overload relay, coil blowdown valve switch, stack switch high temperature contacts or low temperature contacts) operates to shut down the steam generator, the alarm will ring and the "boiler off" signal will flash on the remote control panel.

Turn the control switch-102 to OFF and use the following instructions as a guide in locating the trouble.



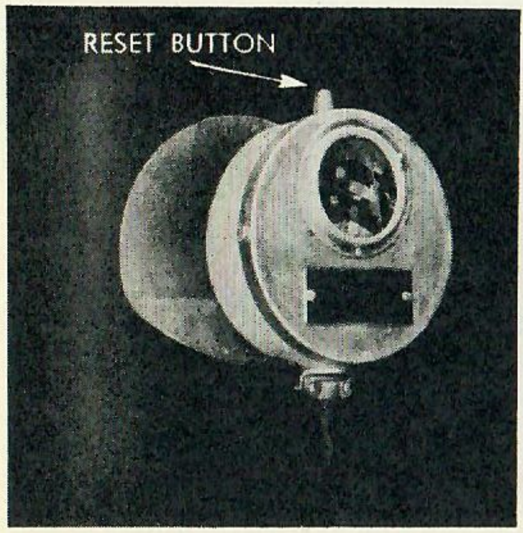
Control Panel on OK-4630
Fig. 10-5

Motor and Burner Shut Down During Operation

1. Blown fuses: The alarm will not ring and the instrument lights will go out. The main fuse (or circuit breaker) is generally located in the low voltage cabinet of the locomotive. Check this fuse, and check the control fuses in the steam generator control cabinet. A test lamp and fuse clips wired inside the control cabinet may be used to check the fuses.

2. Overload reset button-106 "out:" The alarm will ring; the instrument lights will remain on. Turn the control switch-102 OFF; check for hot blower-202 or water pump-230 bearings and for poorly adjusted pulley belts. Check the setting of the belt tension adjuster. Push the overload reset button "in."

3. Stack switch-109 reset button "out:" The high temperature contacts in the stack switch are open; the alarm will ring and the instrument lights will remain on. Turn the control switch-102 to OFF; open the separator blowdown valve-12 and drain the steam separator-221. Close the separator blowdown valve, push in the stack switch reset button, refill the coils with water, and then start the steam generator.



Stack Switch
Fig. 10-6

4. Coil blowdown valve-2 partially open: The alarm will ring, the instrument lights will remain on. Be sure the locking pin on the coil blowdown valve handle is properly seated in the closed position.

Motor Starts But Burner Does Not

If the fire fails to light, the low temperature contacts on the stack switch-109 will not close, and after a 45 second time delay the outfire relay will open the circuit to shut down the steam generator. The alarm will ring and the instrument lights will remain on. Turn the control switch-102 OFF and check the following list for possible causes for the burner failure.

1. Ignition failure: Turn control switch to RUN—no spark visible through the peep hole glass, or spark is of low intensity. If an ignition fuse is blown or if the current flow is broken for any other reason, the ammeter in the ignition circuit registers zero when the ammeter test button is pressed in. If the ammeter registers below normal, the spark plug electrodes are dirty or too far apart. If the ammeter registers above normal the electrodes are too close together, or the ignition circuit is grounded.

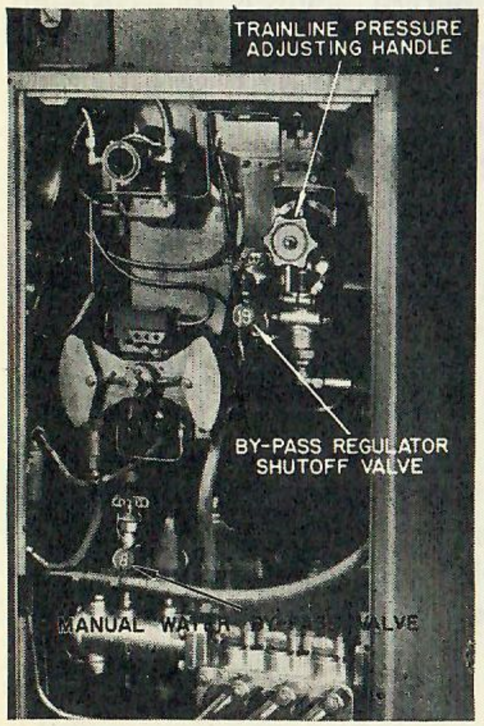
   Check the ignition fuses—use the test lamp and clips installed in the control cabinet for that purpose. Tighten loose cable connections and replace chafed or broken wire which may be breaking or grounding the circuit.

2. Low atomizing air pressure-201: The air switch-101 opens and breaks the circuit to the fuel solenoid valve-104, which then stops the flow of fuel to the sprayhead-105.

Be sure the air admission valve is fully open. Clean the strainer screen in the atomizing air line and drain the atomizing air pressure regulator-100. If the low atomizing air pressure persists, tighten the adjusting screw at the top of the air pressure regulator to increase the atomizing pressure.

3. Low fuel manifold pressure-208: Turn the handle on the suction line fuel filter-206 several times. A slight suction leak may cause the manifold pressure to build up slowly; put the control switch-102 on FILL to bleed the fuel line and bring the manifold pressure up to normal.

4. Low fuel nozzle pressure-207: Lack of water causes the servo fuel control-108 to limit the supply of fuel entering the nozzle. (If the water supply is almost completely stopped, the cam plate may come down far enough to actuate the cutout switch on the servo and close the fuel solenoid valve-104.)


TRAINLINE PRESSURE ADJUSTING HANDLE
19
BY-PASS REGULATOR SHUTOFF VALVE
MANUAL WATER BY-PASS VALVE

Feed Water Controls
OK-4630
Fig. 10-7

Be sure that the pump belts have proper tension, the water pump test valve-18 is closed, the cover on the water treatment or strainer tank-234 is tight, the three-way washout valve-17 is fully open, and that the drain valves-20 and 22 are tightly closed.

Open and close the water by-pass regulator-111 adjusting handle several times to free the regulator from possible sediment. If the water pressure gauge-229 still registers low, close the water by-pass regulator shutoff valve-19. This closes the water by-pass line and permits all of the feed water to flow to the servo-fuel control-108; the steam generator will start at once if the by-pass regulator is causing the trouble. Set and manually regulate the trainline steam pressure by adjusting the manual water by-pass valve-8.

High feed water temperature or leaky water line connections may cause the water pump-230 to become air or vapor bound. Violent fluctuation of the water pressure gauge needle indicates this condition. Tighten leaky water line connections and bleed the line by opening the water pump test valve-18. Allow water to flow from this valve until no air or vapor bubbles are evident in the water.

Irregular Trainline Pressure

1. Burner cycles off and on: Insufficient water delivery causes the steam generator to run in superheat; the steam temperature limit control-110 operates to protect the coils against overheating. Check the water pump output as instructed in the preceding paragraphs.

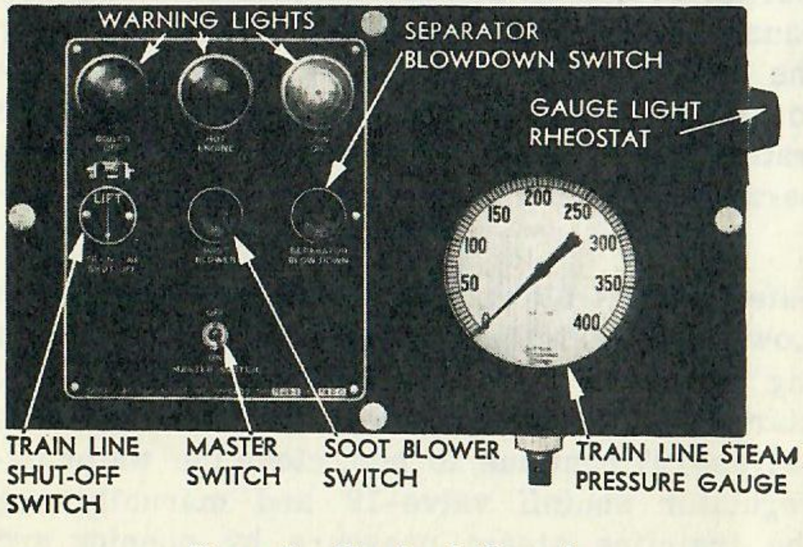
2. Safety valves blow: Shut down the steam generator. Lower the trainline pressure setting on the adjusting handle of the water by-pass regulator-111 and start the steam generator again. If the safety valves-107 continue to pop, close the water by-pass regulator shutoff valve-19 and manually regulate the trainline steam pressure by opening and adjusting the manual water by-pass valve-8.

REMOTE CONTROL EQUIPMENT

The remote control panel is located on the fireman's side of the locomotive cab. Mounted on it are a master switch to make the panel operative, and push-button switches to operate the separator blowdown valve-12 and the remote control trainline shutoff valve-7. Three warning lights are mounted on the panel and connected to the alarm circuit of the locomotive. The lights are marked "boiler off," "hot engine" and "low oil." A trainline steam pressure gauge is mounted on the panel.

A soot blower switch is also provided. It is to be used only when a steam generator of the CFK type is included in the installation.

The remote control trainline shutoff valve-7 can be closed from the cab; it must be opened manually, however. Depress the reset lever-7a on the trainline shutoff valve-7 to the position marked "open."


WARNING LIGHTS
SEPARATOR BLOWDOWN SWITCH
GAUGE LIGHT RHEOSTAT
LIFT
150
200
250
100
300
50
350
0
400
TRAIN LINE SHUT-OFF SWITCH
MASTER SWITCH
SOOT BLOWER SWITCH
TRAIN LINE STEAM PRESSURE GAUGE

Remote Control Panel
Fig. 10-8

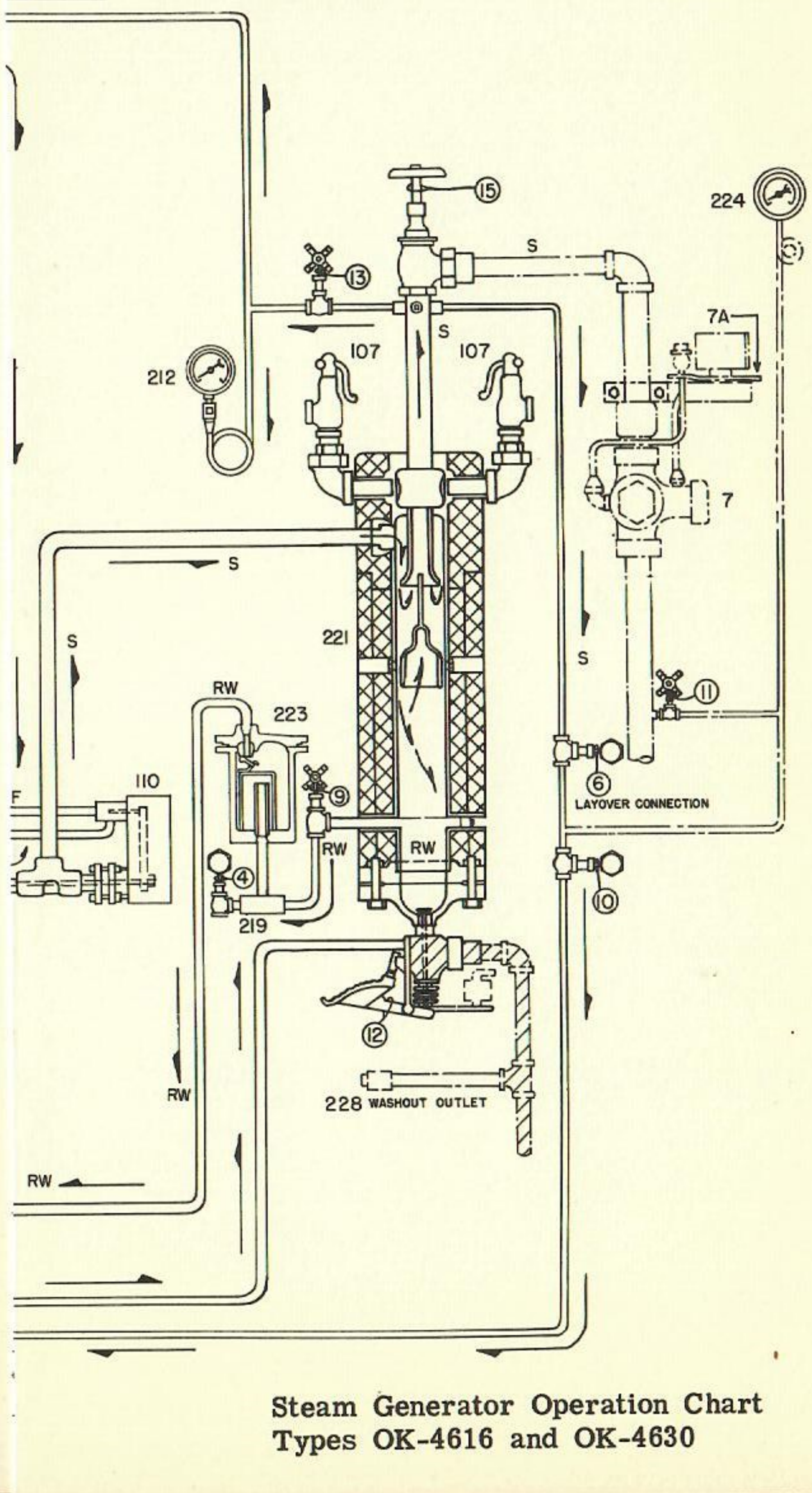
ITEMS TO REPORT

1. Water pressure greater than 450 pounds at any time.
2. Excessive stack temperature.
3. Fluctuation of the fuel manifold pressure.
4. Frequent cycling of the burner.
5. Water flow indicator not cycling.
6. Water by-pass regulator inoperative.
7. Faulty operation of the steam generator for any reason.

NOTES

e regulator)

217. Radiation
218. Return Water Flow Indicator
219. Return Water Strainer
220. Spark Plugs
221. Steam Separator
222. Steam Trap (Radiation)
223. Steam Trap (Return water line)
224. Trainline Steam Pressure Gauge
225. Treatment Injector Filter
226. Treatment Injector Gauge
227. Washout Solution Inlet
228. Washout Solution Outlet
229. Water Pressure Gauge
230. Water Pump
231. Water Strainer Manifold
232. Water Tank
233. Water Treatment Injector Pump
234. Water Treatment Tank (Strainer tank only if injector system is used)


⑮
224
⑬
S
107
107
S
212
7A
7
S
S
221
S
⑪
RW
223
110
⑨
⑥
LAYOVER CONNECTION
F
RW
RW
④
219
⑩
⑫
RW
228 WASHOUT OUTLET
RW

Steam Generator Operation Chart
Types OK-4616 and OK-4630

VALVES

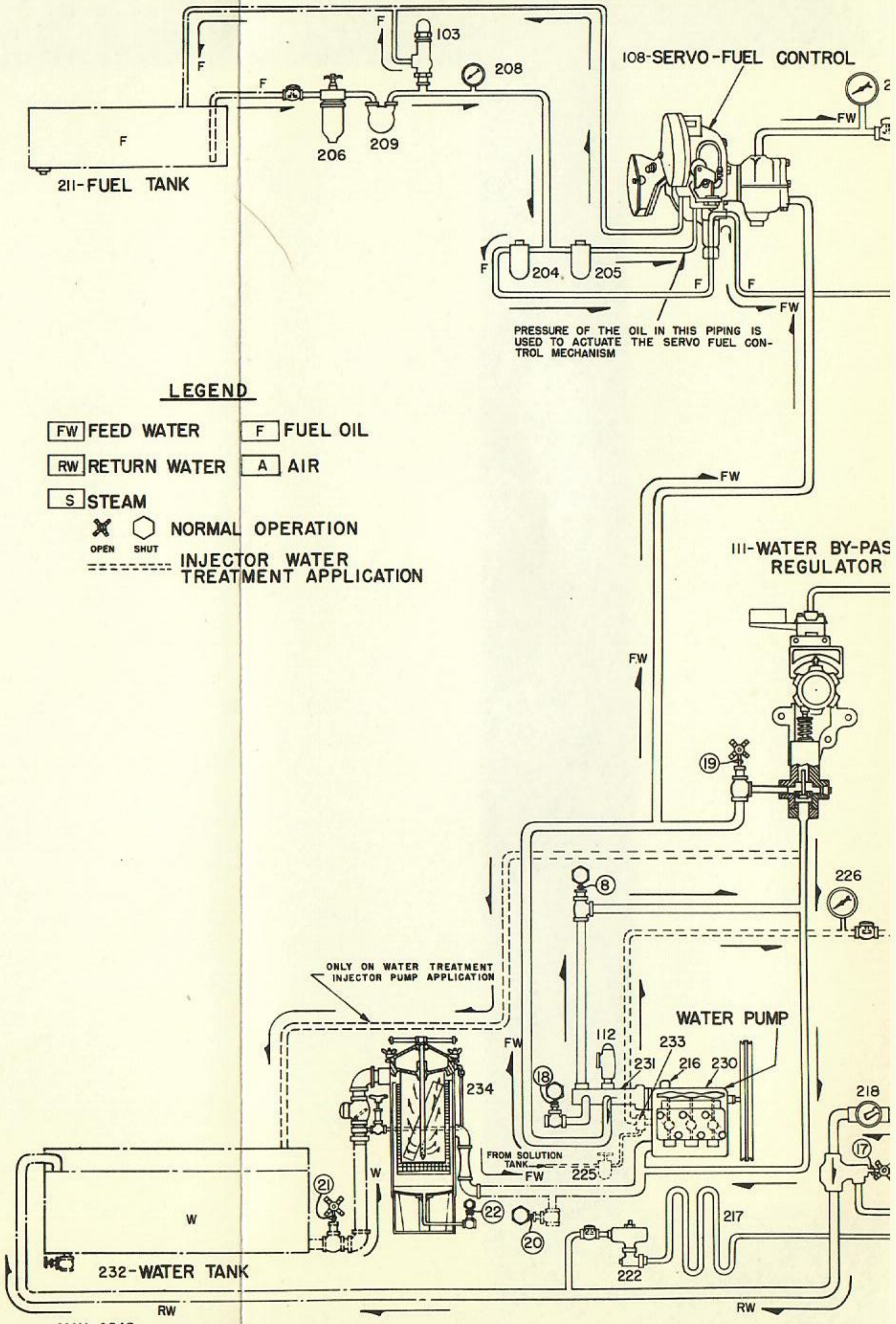
Valves designated by odd numbers must be OPEN during normal operation of the steam generator. Valves designated by even numbers must be CLOSED during normal operation of the steam generator. Normally open valves are fitted with a cross type handle; normally closed valves are fitted with the standard round handle. These designations apply only to the OK series steam generators.

The following valves must be OPEN during normal operation of the steam generator:

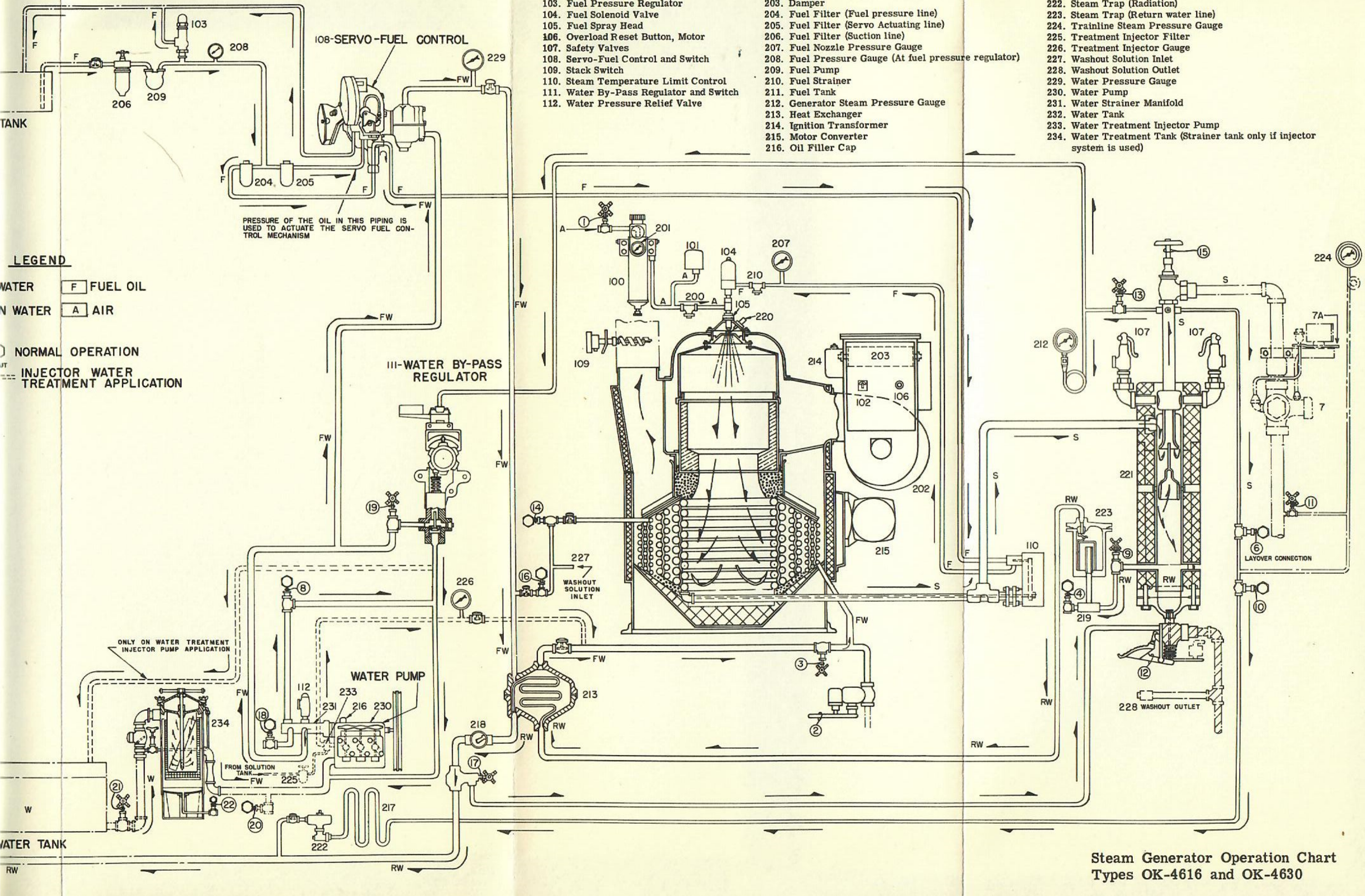
1. Atomizing Air Shutoff Valve
3. Coil Shutoff Valve
7. Remote Control Trainline Shutoff Valve
7a. Reset Lever
9. Return Water Outlet Valve
11. Steam Admission Valve to Trainline Pressure Gauge
13. Steam Admission Valve to Water By-Pass Regulator
15. Stop and Check Valve
17. Three-Way Washout Valve
19. Water By-Pass Regulator Shutoff Valve
21. Water Supply Stop Valve

The following valves must be CLOSED during normal operation of the steam generator:

2. Coil Blowdown Valve and Switch
4. Fill-Test Valve
6. Layover Connection Shutoff Valve
8. Manual Water By-Pass Valve
10. Steam Admission Valve to Radiation (Open in cold weather)
12. Steam Separator Blowdown Valve
14. Washout Inlet Valve
16. Washout Inlet Valve
18. Water Pump Test Valve
20. Water Suction Line Drain Valve
22. Water Treatment Tank Drain Valve


F
103
208
108-SERVO-FUEL CONTROL
FW
F
206
209
211-FUEL TANK
F
204
205
F
F
FW
PRESSURE OF THE OIL IN THIS PIPING IS USED TO ACTUATE THE SERVO FUEL CONTROL MECHANISM
LEGEND
FW FEED WATER
F FUEL OIL
RW RETURN WATER
A AIR
S STEAM
OPEN
SHUT
NORMAL OPERATION
INJECTOR WATER TREATMENT APPLICATION
FW
111-WATER BY-PAS
REGULATOR
FW
19
226
8
ONLY ON WATER TREATMENT INJECTOR PUMP APPLICATION
WATER PUMP
112
233
231
216
230
FW
18
234
218
17
FROM SOLUTION TANK
FW
225
21
W
W
22
20
217
222
232-WATER TANK
RW
RW

MAY, 1948



103
F
208
108-SERVO-FUEL CONTROL
229
FW
206
209
TANK
204
205
PRESSURE OF THE OIL IN THIS PIPING IS USED TO ACTUATE THE SERVO FUEL CONTROL MECHANISM
LEGEND
WATER
F FUEL OIL
N WATER
A AIR
NORMAL OPERATION
INJECTOR WATER TREATMENT APPLICATION
111-WATER BY-PASS REGULATOR
A
201
101
104
207
210
100
200
105
220
109
214
203
106
102
202
215
110
S
212
107
7A
7
221
224
223
219
RW
LAYOVER CONNECTION
227
WASHOUT SOLUTION INLET
226
213
218
217
222
225
FROM SOLUTION TANK
WATER PUMP
233
231
216
230
112
234
ONLY ON WATER TREATMENT INJECTOR PUMP APPLICATION
W
WATER TANK
228 WASHOUT OUTLET

CONTROLS

100. Atomizing Air Pressure Regulator
101. Atomizing Air Switch
102. Control Switch
103. Fuel Pressure Regulator
104. Fuel Solenoid Valve
105. Fuel Spray Head
106. Overload Reset Button, Motor
107. Safety Valves
108. Servo-Fuel Control and Switch
109. Stack Switch
110. Steam Temperature Limit Control
111. Water By-Pass Regulator and Switch
112. Water Pressure Relief Valve

APPURTENANCES

200. Atomizing Air Strainer
201. Atomizing Air Pressure Gauge
202. Blower
203. Damper
204. Fuel Filter (Fuel pressure line)
205. Fuel Filter (Servo Actuating line)
206. Fuel Filter (Suction line)
207. Fuel Nozzle Pressure Gauge
208. Fuel Pressure Gauge (At fuel pressure regulator)
209. Fuel Pump
210. Fuel Strainer
211. Fuel Tank
212. Generator Steam Pressure Gauge
213. Heat Exchanger
214. Ignition Transformer
215. Motor Converter
216. Oil Filler Cap
217. Radiation
218. Return Water Flow Indicator
219. Return Water Strainer
220. Spark Plugs
221. Steam Separator
222. Steam Trap (Radiation)
223. Steam Trap (Return water line)
224. Trainline Steam Pressure Gauge
225. Treatment Injector Filter
226. Treatment Injector Gauge
227. Washout Solution Inlet
228. Washout Solution Outlet
229. Water Pressure Gauge
230. Water Pump
231. Water Strainer Manifold
232. Water Tank
233. Water Treatment Injector Pump
234. Water Treatment Tank (Strainer tank only if injector system is used)

Steam Generator Operation Chart
Types OK-4616 and OK-4630

SECTION 11

LOCATION AND CORRECTION OF DIFFICULTIES*

STARTING ENGINE

1101. Engine Does Not Rotate When "START" Button Is Pressed

1. Check condition of battery by observing engine room lights when "START" button is pressed. If lights go out or nearly out, battery is weak.
2. Check operation of starting contactors in unit concerned. If the contactors fail to operate, the causes may be:
   - a. Main battery switch open in distribution panel of operating "A" unit (If engine in that unit is stopped).
   - b. Main control switch open (same location).
   - c. Main control fuse (80 amp.) blown (same location).
   - d. Control fuse (30 amp.) blown (same location).
   - e. Control push-button switch open in operating "A" unit.
   - f. Isolation switch not fully in "START" position.
   - g. Defective "START" switch.
3. If the starting contactors operate when "START" button is pressed, check for:
   - a. Poor starting contactors contact.
   - b. Starting fuse (400 amp.) blown or main switch open in electrical control cabinet of unit concerned.

*On locomotives not equipped with dynamic brake, disregard reference to Cam-Switch or Brake Relay.

1102. Engine Rotates But Does Not Fire When "START" Button Is Pressed

1. Check fuel flow through fuel return sight glass. If no fuel, see Art. 1115.
2. Check to see that overspeed trip shaft is latched in "Run" position.
3. Check cylinder test valves at each cylinder, making sure that they are closed.
4. Check layshaft in event that it may be stuck in shut-down position.
5. Check button on front of governor housing - should be "in."

LOCOMOTIVE DOES NOT MOVE WHEN THROTTLE IS OPENED

1103. Engines Do Not Speed Up

If engines DO NOT SPEED UP, when throttle is opened, causes may be:

1. Control switch open in distribution panel of operating "A" unit.
2. Main control fuse (80 amp.) blown - same location.
3. Control switch open in control push-button switch box.
4. Control fuse (30 amp.) blown in distribution panel of operating unit.
5. Fuel pump switch open in control push-button switch box.
6. Fuel pump fuse (15 amp.) blown in distribution panel of operating "A" unit.
7. PC switch tripped.

1104. Engines Speed Up

If all the engines SPEED UP when the throttle is opened, check for:

1. Hand brakes set in one or more units.
2. Generator field switch open in control push-button switch box.
3. Reverse lever in neutral.
4. Train or independent air brakes applied.
5. Starting contactors stuck in one or more units.
6. Control switch must be in "Off" position in any trailing units.

LOCOMOTIVE STOPS IN OPERATION

1105. Check for conditions listed above for LOCOMOTIVE DOES NOT MOVE, except 2a.

LOCOMOTIVE FAILS TO DEVELOP FULL POWER

1106. Check speed and loading of the engines of all units. To detect a loss of speed or load by any engine, check the "SPEED" and "FUEL" indicators on the sides of the governor housings. The 'SPEED" pointers should be at the mark corresponding in number to the locomotive throttle position. The proper position of the "FUEL" pointer will depend on the throttle setting. When the throttle is in Run 8, the "FUEL" pointers should be approximately at "6" (mark halfway between "5" and "7"), providing the transition lever is in the proper position as indicated by the transition meter. If the unit is not loading properly, the "FUEL" pointer will read higher than "6" (to the left of the mark) with the throttle in Run 8. Should the throttle be in Run 7 or lower, the "FUEL" pointer will read higher than 6 with normal loading of the engine. Under reduced throttle conditions, it is preferable to compare the positions of the "FUEL" pointers on the various units. If one reads considerably higher than the rest, that unit should be checked for failure to load properly.

1107. Engine at Idle

If the engines of one or more units are at idle, and will not speed up under throttle control, check for following causes at units concerned.

1. Ground protective relay tripped.
2. Isolation switch not fully in "RUN" position.
3. No AC Voltage Relay contacts open or dirty.
4. "ER" relay de-energized or contacts open.

NOTE: On (3), above, the relay will be in normal operating position, but the contacts for that position will be found to be open or dirty. If the relay is in the "alarm" position, such contacts will be open, causing lack of power, but opposite contacts will be closed to actuate the alarm bells and light "ALTERNATOR FAILURE." light.

1108. Speed of Engine Differs from Cab Setting of Throttle

If the readings of one or more "SPEED" pointers on the governors do not correspond with the throttle run position, check the contacts of the "ER" relay in the engine control panel. If all the "SPEED" pointers read the same but do not agree with the throttle position, the probable cause is dirty, or defective, contacts in the controller.

1109. Engine Does Not Load

If engines of one or more units speed up, but fail

to load properly, check for:

1. Shunt field contactor open (See "SHUNT FIELD CONTACTOR FAILS TO CLOSE").
2. Battery field contactor open (See "BATTERY FIELD CONTACTOR FAILS TO CLOSE").
3. Battery field fuse (80 amp.) blown in electrical control cabinet.
4. Either wheel slip relay picked up and stuck in closed position. If this condition exists, wheel slip indicator light will show in operating cab.
5. P, S, & M contactors not in position corresponding to transition lever settings. If all line contactors are out, check position of reverser drum, cam-switch, brake relay and braking contactors and for control air. Check for open or dirty interlocks on this equipment and also on P1 and P2. If line contactors are set up for motor hookup different from the one called for by transition lever setting check for cause as given under "FAILURE TO MAKE TRANSITION - ONE UNIT." Should the condition exist in all units the causes are listed under "FAILURE TO MAKE TRANSITION - ALL UNITS."
6. Starting contactors stuck closed or interlocks not making proper contact.

1110. Miscellaneous Possible Causes of Lack of Power

Some of the listed items will affect the locomotive as a whole, others will act on one unit only. If the conditions are observed, report to maintenance for correction.

1. Low excitation of main generator fields due to faulty auxiliary generator or voltage regulator. Poor connection in main generator battery

field circuit or defective load regulator.
2. Fuel conditions - poor quality, dirt, water, etc.
3. Engine - restriction in exhaust, incorrect timing, leaky exhaust valves, defective injectors, improperly set pilot valve linkage, binding of linkage, or layshaft, etc.
4. Traction motor trouble.

ENGINE STOPPED

1111. When one or more engines stop, the alarm bells will sound throughout the locomotive. The blue "ALTERNATOR FAILURE" lights will light in the unit or units concerned. If the stoppage is due to low lube oil pressure or excessive oil pump suction, the yellow "LOW OIL" lights will also light in that unit and the governor reset button will be found "OUT."

1112. No Yellow Light

On engine stopped, governor reset button "in" and "LOW OIL" lights not showing. Place isolation switch in "START" position to stop the alarm bells. Check for most usual causes:

1. Lack of fuel. Check fuel pump operation and fuel supply as explained under "NO FUEL SHOWS IN FUEL RETURN SIGHT GLASS.
2. Overspeed Trip. Check position of overspeed trip lever and reset if necessary.
3. Ground Protective Relay. Examine ground protective relay and re-set if necessary.
4. "No AC Voltage" relay contacts open or dirty.
5. ER Relay contacts open or dirty.

NOTE: Items (3), (4) and (5) will cause engine to stop only if throttle is in Run 5 or Run 6.

1113. Yellow Light – One Engine Stopped

Governor re-set button "out" and yellow "LOW OIL" lights showing.

1. Push in governor reset button and place isolation switch in "START" position to stop alarm bells.
2. Start engine and allow it to idle for approximately one minute before placing engine on the line. The engine will stop again during this period if oil pressure is at fault. In case of such indication of defect in the lubricating oil system, do not attempt to use unit.

1114. All Engines Stopped

Check the following items: Note that items (2), (3) and (4) will usually not cause the engines to stop simultaneously.

1. Locomotive throttle in "Emergency Stop" position.
2. Fuel pump switch open in control push-button box.
3. Fuel pump fuse (15 amp.) blown in distribution panel of operating unit.
4. PC switch tripped.

FUEL DOES NOT SHOW IN FUEL RETURN SIGHT GLASS

1115. Fuel Pump Stopped

NOTE: First check operation of fuel pump in adjacent unit. If it also is stopped, check items (1) to (6). If it is running or if the

11

other units are operating under power, items (7) to (14) only need be checked.

1. Main battery switch open in operating "A" unit (when engine in that unit is stopped).
2. Control switch open in distribution panel of operating "A" unit.
3. Main control fuse (80 amp.) blown in distribution panel of operating unit.
4. PC switch tripped.
5. Fuel pump switch open in control push-button switch box.
6. Fuel pump fuse (15 amp.) blown in distribution panel of operating unit.
7. Fuel pump switch off at engine control panel.
8. Defective fuel pump contactor.
9. Main battery switch open in unit concerned.
10. Control switch open in distribution panel of unit concerned.
11. Control fuse (80 amp.) blown in distribution panel of unit concerned.
12. Fuel pump motor fuse (10 amp.) blown in distribution panel of unit concerned.
13. Loose connection at engine control panel or cable to fuel pump.
14. Defective fuel pump motor.

1116. Fuel Pump Running

Check for following:

1. Lack of fuel supply.
2. Clogged pump suction filter.
3. Emergency fuel cutoff valve closed.
4. Air leaks in pump suction line due to broken pipe or loose connection. This condition or (2) may first result in a decrease in fuel flow in the sight glass. So long as any fuel flows, no action is necessary but the sight glass should be checked frequently. If the condition becomes aggravated, the sight glass flow will disappear and the engine may "Hunt" or run eratically when speeded up. When this action is noted, take the engine off the line and shut it down. If opportunity affords, take out the fuel pump suction filter element and replace cap. This will remedy condition if it has been due to item (2).
5. Clogged elements in sintered bronze filter assembly causing relief valve to open and by-pass oil through 45 pound sight glass. This defect will usually cause a preliminary dribble to appear in the 45 pound sight glass, giving warning that a clogged filter condition exists. As the condition becomes worse, the dribble will increase until enough fuel is by-passed to cause the engine to starve for fuel. Shut down engine and report to maintenance for correction.

1117. Bubbles in Fuel Return Sight Glass

If condition becomes so pronounced as to interfere with proper operation or loading of the engine, take the engine off the line and shut it down. Otherwise, continue operation and report condition to maintenance.

MISCELLANEOUS

1118. Hot Engine Alarm Sounds

1. Check alarm lights to determine which engine is causing alarm.
2. Take engine off the line.
3. Check for cause - inoperative shutters, fans not running, low water, defective water cir-

culating pump, or circulation. See "COOLING SYSTEM FAN MOTORS AND SHUTTERS FAIL TO OPERATE - ONE UNIT."

4. Stop engine if cause cannot be located and corrected.

1119. Air Pressure Does Not Build Up

1. Check to see that angle cocks and main reservoir drain valves are in proper position.
2. Check main reservoir safety valve in event that it might be stuck open.
3. Check compressor control switches for sticking in "unloading" position.

ELECTRICAL DIFFICULTIES

1120. Ground Protective Relay Tripped

The cause for tripping of the ground protective relay is usually not apparent. BEFORE RE-SETTING: ISOLATE THE ENGINE. Start the engine in the usual way, if stopped, and place on the line. After starting the engine, check the position of the ground protective relay as it may trip due to a low voltage system ground. If the ground protective relay continues to trip each time the engine is put on the line, isolate the engine and shut it down.

1121. Alternator Failure

Blue light will show only in unit affected. Cause of difficulty may be:

1. No output from auxiliary generator due to:
   a. Auxiliary generator field fuse (30 amp.) blown in electrical control cabinet.

   b. Defective auxiliary generator.

NOTE: Stop engine before removing 30 amp. auxiliary generator field fuse.

2. Alternator field fuse (35 amp.) blown in electrical control cabinet.

1122. Cooling System Fan Motors and Shutters Fail to Operate – One Unit

1. Fuel pump switch open at engine control panel.
2. Fuel pump motor fuse (10 amp.) blown in distribution panel.
3. Thermostat switch defective.
4. Transfer relay contacts open or dirty.
5. Temperature control relay not working or contacts dirty.
6. AC contactors not working or contacts dirty. Each contactor will affect operation of corresponding fan motor only.
7. Thermal overload protective devices open because of overload or defective contacts. Reset if necessary.
8. Magnet valve defective (shutter operation only.)

1123. Cooling System Fan Motors and Shutters Fail to Operate – All Units

1. PC switch tripped in operating unit.
2. Fuel pump switch open in control push box of operating unit.
3. Fuel pump fuse (15 amp.) blown in distribution panel of operating unit.

1124. Auxiliary Generator Ammeter Always Reads Zero

Alternator failure alarm should sound. For possible defects see "ALTERNATOR FAILURE."

1125. Auxiliary Generator Ammeter Reading Fluctuates

The causes may be voltage regulator defective or set so low that reverse current relay opens and closes. Continue unit in operation if "Alternator Failure" alarm does not sound.

1126. Battery Ammeter Always Shows Discharge

The auxiliary generator is failing to supply the current demands of the low voltage circuits. If this condition continues unit will fail as battery runs down. Check for:

1. Battery charging fuse (150 amp.) blown in electrical control cabinet of unit concerned.
2. Auxiliary generator switch open - same location.
3. Voltage regulator set too low. Report to maintenance for attention if check of (1) and (2) above shows no defect.

1127. Reverser Drum Fails to Operate when Reverse Lever Is Moved – One Unit

1. Control air pressure low or cut out.
2. Defective magnet valve.
3. Reverser drum sticking due to lack of lubrication or welding on contact surfaces.

1128. Reverser Drums Fail to Operate when Reverse Lever Is Moved – All Units

1. Throttle not moved to Run 1 if transition lever in No. 1 position.
2. Main control switch open in distribution panel.

3. Main control fuse (80 amp.) blown on distribution panel.
4. Control switch open in control push-button box.
5. Control fuse (30 amp.) blown in distribution panel.
6. Generator field switch open in control push-button box.
7. Low control air pressure in each unit of the locomotive.
8. Defective contacts in controller stand.
9. Controls not cut out at other operating stations.

1129. Cam-Switch Fails to Move from "TOW" to "MOTOR" – One Unit

1. Reverser drum not in position corresponding to reverse lever setting.
2. Interlock on reverser open or making poor contact.
3. Braking contactors stuck closed.
4. Brake relay contacts open or dirty.
5. Low control air pressure.
6. Defective magnet valve.
7. Cam-switch sticking due to lack of lubrication or welding of contact surfaces from arcing.

1130. Cam-Switch Fails to Move from "MOTOR" to "TOW" – One Unit

1. Brake relay not operating.
2. Brake relay contacts open or dirty.
3. Low control air pressure, defective magnet valve or sticking cam-switch as in (7) above.

1131. Cam-Switches Fail to Move from "TOW" to "MOTOR" – All Units

When the cam-switches fail to move from "TOW" to "MOTOR" when the transition lever is moved from "OFF" to No. 1 position and the throttle moved to Run 1, the causes may be:

1. Control air pressure low in all units of the locomotive.
2. Main control switch open in distribution panel of operating unit.
3. Main control fuse (80 amp.) blown - same location.
4. Control switch open in control push-button box of operating unit.
5. Control fuse (30 amp.) blown in distribution panel of operating unit.
6. Generator field switch open in control push-button switch box.
7. Reverse lever in neutral position.
8. Contacts in controller stand open or dirty.
9. Throttle not moved to Run 1 after transition lever is moved to No. 1 position.
10. Control push-button in other control station must be in open position.

1132. Cam-Switches Fail to Move from "MOTOR" to "TOW" – All Units

Cam-switches fail to move from "MOTOR" to "TOW" when the transition lever is moved to "OFF" position - all units.

1. Control air pressure low in all units of the locomotive.
2. Main control switch open in distribution panel of operating unit.
3. Main control fuse (80 amp.) blown - same location.
4. Control switch open in control push-button box

of operating unit.

5. Control fuse (30 amp.) blown in distribution panel of operating unit.
6. Contacts in controller stand open or dirty, not energizing wire "B" throughout locomotive. Condition may be recognized by noting that brake relays in all units fail to move to dynamic braking position.

1132. Generator Shunt Field Contactor Does Not Close – One Unit

1. Isolation switch not fully in RUN position.
2. Either or both starting contactors stuck closed or interlocks open or dirty.
3. Cam-switch in "TOW" instead of "MOTOR."
4. Ground protective relay tripped.
5. Parallel relay contacts open or dirty.
6. P3 contactor interlocks open or dirty.
7. S14 or S23 contactor interlocks open or dirty.
8. Either wheel slip relay closed.
9. Defective 35 ohm resistor.

1134. Generator Shunt Field Contactors Do Not Close – All Units

Open throttle to determine whether engines speed up under throttle control. If engines do not respond, make check of items listed under "LOCOMOTIVE DOES NOT MOVE WHEN THROTTLE IS OPENED," Art. 1103. If engines speed up, check for:

1. Generator field switch open.
2. All cam-switches in "TOW" instead of "MOTOR." (See "CAM-SWITCHES WILL NOT OPERATE - ALL UNITS.")

1135. Battery Field Contactor Fails to Close – One Unit or All Units

Check operation of corresponding shunt field contactor or contactors. If they are open, check for causes first. If shunt field contactors are closed check interlocks thereon which complete the battery field contactor operating circuit.

FAILURE TO MAKE MANUAL TRANSITION—ONE UNIT

1136. Make sure throttle is in Run 1 or higher since all contactors are open when the throttle is in IDLE. Check control air pressure as insufficient pressure will prevent contactor operation and hence transition.

Check position of contactors, cam-switch and reverser drum BY OBSERVATION ONLY. Having determined what step the contactors are failing to make, ISOLATE AND STOP engine. Consult list below. It indicates the probable defects which may be the causes of failure to make the various transitions. The list omits mechanical defects in the contactors such as inoperative magnet valves, broken air lines, defective air cylinders, etc. These may be located by operating the contactors manually, WITH ENGINE ISOLATED AND STOPPED, by pressing the buttons on the magnet valves. In listing the possible defects "interlock open" means either actually open or making poor contact by reason of dirt or scale.

While checking the items, the transition action may be tested at any time by placing the isolation switch in "RUN" with the ENGINE STOPPED. The contactors should then assume the proper positions for the transition lever setting if the defect has been corrected. The alternator failure alarm will sound while such tests are being made but may be disregarded.

Sequence Test In Shop

The following paragraphs may be followed for a step by step sequence test while the locomotive is in the shop.

With all switches set in operating position, control air pumped up and engines shut down, transition may be followed through step by step by proper manipulation of throttle, reverse lever and transition lever.

The same items are checked when correcting troubles that may develop while locomotive is on the road.

1137. Unit Will Not Make Transition "Off" to 1

1. Isolation switch not fully in "Run" position, or fingers not making good contact.
2. Braking contactors stuck in braking position, or interlocks B-AB and BR-EF not making good contact.
3. Cam-switch stuck in TOW position, or interlock CS-AB not making good contact.
4. P1, P2, P3 or P4 contactors stuck closed, or the following interlocks not making good contact. P1-AB, P1-CD, P4-CD.
5. Reverse lever in neutral.
6. Reverser drum not in full Forward or Reverse position, or FOR-CD or REV-EF interlocks, (depending on direction of reverser) not making good contact.
7. FO or RE wire (depending on direction of reverser handle) not energized.
8. PR stuck closed. Closed PR-CD interlock could energize P contactor, holding them closed.
9. VT stuck open, VT-CD interlock not making good contact, holding S contactors open.

10. Wire to reverser not energized by GF when transition lever is placed in #1 position.

1138. Unit Will Not Make Transition 1 to 2

1. M wire not energized with transition lever in #2 position.
2. SH or BF stuck open. BF interlock GH not making good contact.
3. M contactor will not pick up.
4. Transition cutout switches not in "Manual" position.
5. SH interlock AB not making good contact.
6. WSR1-WSR2 picked up shorting out SH and BF.
7. ST+ or ST- stuck closed. ST+ and ST- interlocks AB not making good contact.
8. CS interlock GH not making good contact.
9. GR picked up. GR interlock AB not making good contact.
10. PR interlock EF not making good contact.
11. S14-S23 interlocks CD not making good contact.
12. P3 interlock AB not making good contact.

1139. Unit Will Not Make Transition 2 to 3

1. P wire not energized with transition lever in #3 position.
2. M contactor stuck closed.
3. M interlock AB not making good contact.
4. PR stuck open. PR interlock CD not making good contact.
5. S contactors stuck closed. S14 interlock AB or S23-AB not making good contact.
6. P contactors stuck open.
7. SH or BF contactors stuck closed. BF interlock EF not making good contact.
8. VT will not pick up.

1140. Unit Will not Make Transition 3 to 4

1. M wire not energized with transition lever in #4 position.

Items listed above preventing transition from 1 to 2 also apply to transition 3 to 4.

The following interlocks open or not making good contact. PR-PN, P2-CD, P3-CD.

1141. Unit Will Not Make Transition 4 to 3

1. M contactor sticking closed.

1142. Unit Will Not Make Transition 3 to 2

1. PR sticking closed.
2. Any of the P contactors stuck closed.
3. SH or BF stuck closed.
4. VT interlock CD or P1 interlocks AB and CD not making good contact.
5. M wire not energized with transition lever in #2 position.
6. The following interlocks not making good contact PR-FE, S14-CD, S23-CD, P3-AB, SH-AB.

1143. Unit Will Not Make Transition 2 to 1

1. M contactor stuck closed.

1144. Unit Will Not Make Transition 1 to "OFF"

1. B wire not energized with transition lever in "Off" position.
2. BR fails to pick up.
3. P2 and P4 interlocks AB not making good contact.
4. Cam-switch fails to go from MOT to TOW.

5. BR interlock AB not making good contact.
6. B fails to pick up.
7. CS interlock EF and FOR or REV interlock AB not making good contact.
8. Finger on isolation switch not making good contact.

FAILURE TO MAKE MANUAL TRANSITION—ALL UNITS

1145. If two or more are coupled and no transition can be made:

1. Transition cutout switches may not be in "Manual" position.
2. Reverser drums may be locked in neutral position.
3. Control air pressure low or none at all.
4. Battery current low or switches open.
5. Defective or dirty contacts in controller stand.

1146. Dynamic Brake Will Not Operate – One Unit

1. Check items listed in "Unit will not go from 1 to Off."
2. BG wire not energized with transition lever in B or beyond.
3. CS interlock CD not making good contact.
4. BF fails to close.
5. Check shorting bar in FL receptacle at rear end of unit.
6. FL circuit may be open.

1147. Dynamic Brake Will Not Operate – All Units

1. Check items for single unit.
2. Check FL jumpers between units. May be open or not making good contact.

3. Dynamic brakes will operate with reverse lever in either Forward or Reverse in the operating cab. Be sure the reverse lever and the reverser drum are always in the direction in which the locomotive is moving, before applying the dynamic brake. If the brake should be applied under the above conditions, it will operate, just as efficiently as though the reverser was in the proper direction, but the current will be going through the transition indicator in the opposite direction, and the indicating needle will try to go in the wrong direction, which will result in damage to the transition indicator.

NOTES

LEGEND OF ELECTRICAL EQUIPMENT

The following is a list of abbreviations used to identify electrical equipment on the schematic wiring diagram. The wire designations appearing on the diagrams conform with the identification bands on the wires throughout the locomotive. These wire designations are not included in this list.

		Reference Art. No.
AC1, AC2, AC3, AC4	Cooling Fan Motor Contactors	701
AV, BV, CV, DV, ER	Electro-Hydraulic Governor Control Solenoids	618
B, B1, B2, B3	Dynamic Braking Contactors (Motor Field Circuit)	723
BA	Boiler Signal Light	
BC	Battery Charging Contactor	707
BF	Battery Field Contactor	707
BOR	Black Out Relay (Mars Headlight)	
BR	Dynamic Brake Relay	713
BTR	Backward Transition Current Relay (Auto. Transition)	622
BW	Dynamic Brake Warning Light	724
BWR	Dynamic Brake Warning Relay	724
CC	Compressor Control Magnet Valve	630
CCS	Compressor Control Switch	630
CL	Class Light or Switch	
COMM	Commutating Field	603
COMP	Compensating Field	603
CO	Cut Out Switch (Automatic to Manual transition)	156

		Reference Art. No.
CR	Compressor Control Relay	630
CS	Cam-Switch (Power-Braking Transfer Switch)	715
DIFF	Differential Field	603
ETS	Engine High Temperature Switch	734
FL	Field Loop Contactor	727
FOR	Reverser Magnet Valve — Forward Position	747
FPC	Fuel Pump Contactor	728
FTR	Forward Transition Voltage Relay (Auto. Transition)	622
G	Ground Light	
GA	Gauge Light or Switch	
GR	Ground Protective Relay	732
HLDT	Headlight	
IL	Load and Transition Indicating Meter Light	
IM	Load and Transition Indicating Meter	117
IS	Isolation Switch	735
LOP	Low Oil Pressure Alarm Switch	739
LOS	Lube Oil Suction Alarm Switch	739
M	Oscillating Motor (Mars Headlight)	
M	Motor Field Shunting Contactor Magnet Valve	759
M1, M2, M3, M4	Motor Field Shunting Contactors	759
MOT	Cam-Switch Magnet Valve — For Power Position	715
N	Number Light or Switch	

		Reference Art. No.
NV	"Alternator Failure" Signal Light	212
NVR	"No AC Voltage" Relay	743
ORS	Overriding Solenoid	744
OS	Low Oil Signal Light	404
P1, P2, P3, P4	Parallel Contactors	758
PCR	Pneumatic Control Relay	745
PCS	Pneumatic Control Switch	746
PR	Parallel Relay	744
R	Red Lens (Mars Headlight)	
RCR	Reverse Current Relay	748
REV	Reverser Magnet Valve — Reverse Position	747
RM	Rotating Motor (Mars Headlight)	
RVR	Reverser Interlock	747
RY	Pole Changer Relay (Mars Headlight)	
S	Series Contactors (S14, S23)	758
SA	Spark Arrester	
SH	Shunt Field Contactor	749
SMV	Shutter Magnet Valve	630
SP	Speed Recorder Light	
SR	Signal Relay	700
ST+, ST-	Starting Contactors	752
START	Starting Field	603
TCR	Temperature Control Relay	630
TD	Time Delay Relay	622
TDB	Time Delay Backward Relay	622
TL	Throttle Light	
TOW	Cam-Switch Magnet Valve — For Dynamic Braking or Towing Position	715
TO1, TO2, TO3, TO4	Thermal Overload Relays	754

		Reference Art. No.
TSA	Thermostat Switch Assembly	755
TS	Engine High Temperature Signal Light	
W	White Lens (Mars Headlight)	
WSR1, WSR2	Wheel Slip Relays	764
WS	Wheel Slip Light	118
VT	No designation (Relay Auto. Transition)	622

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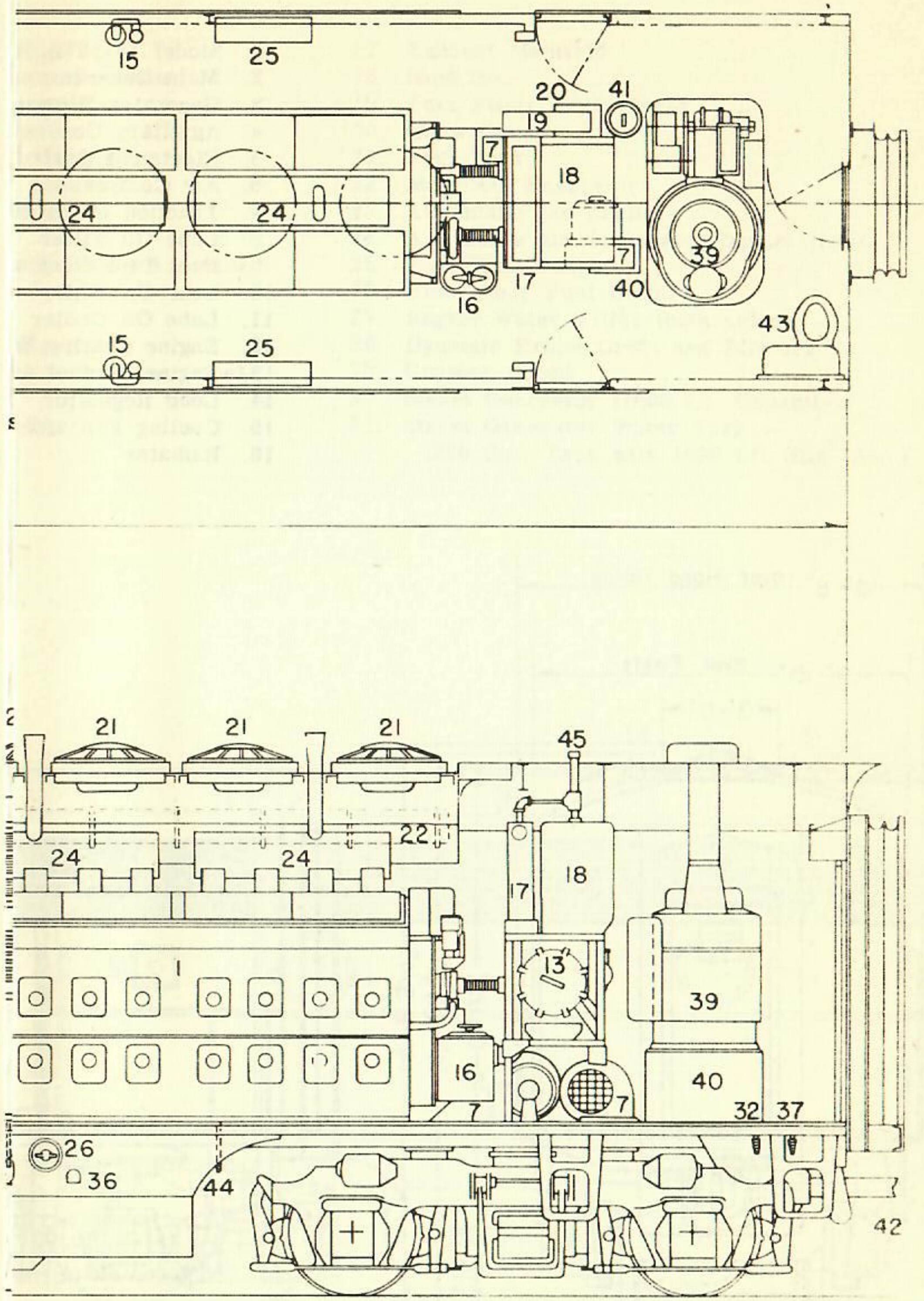
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Charts I and II - General Arrangement - "A" Unit, - "B" Unit (On Reverse Side)

1. Model 16-567B Engine
2. Main Generator and Alternator
3. Generator Blower
4. Auxiliary Generator
5. Electrical Control Cabinet
6. Air Compressor
7. Traction Motor Blower
8. Instrument Panel
9. Controller
10. Speed Indicator
11. Air Brake Valve
12. Cab Heater
13. Lube Oil Filter
14. Hand Brake
15. Fuel Tank Vent with Flame Arrestor
16. Lube Oil Filler
17. Lube Oil Cooler
18. Engine Cooling Water Tank
19. Engine Control and Instrument Panel
20. Load Regulator
21. Cooling Fan and Motor
22. Radiator
23. Horn
24. Exhaust Manifold
25. Sand Box
26. Fuel Filler (both sides)
27. Headlight
28. Batteries
29. Fuel Tank
30. Main Air Reservoir
31. Air Intake Engine Cooling
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33. Air Intake for Grids
34. Fuel Tank Gauge
35. Door
36. Emergency Fuel Cutoff
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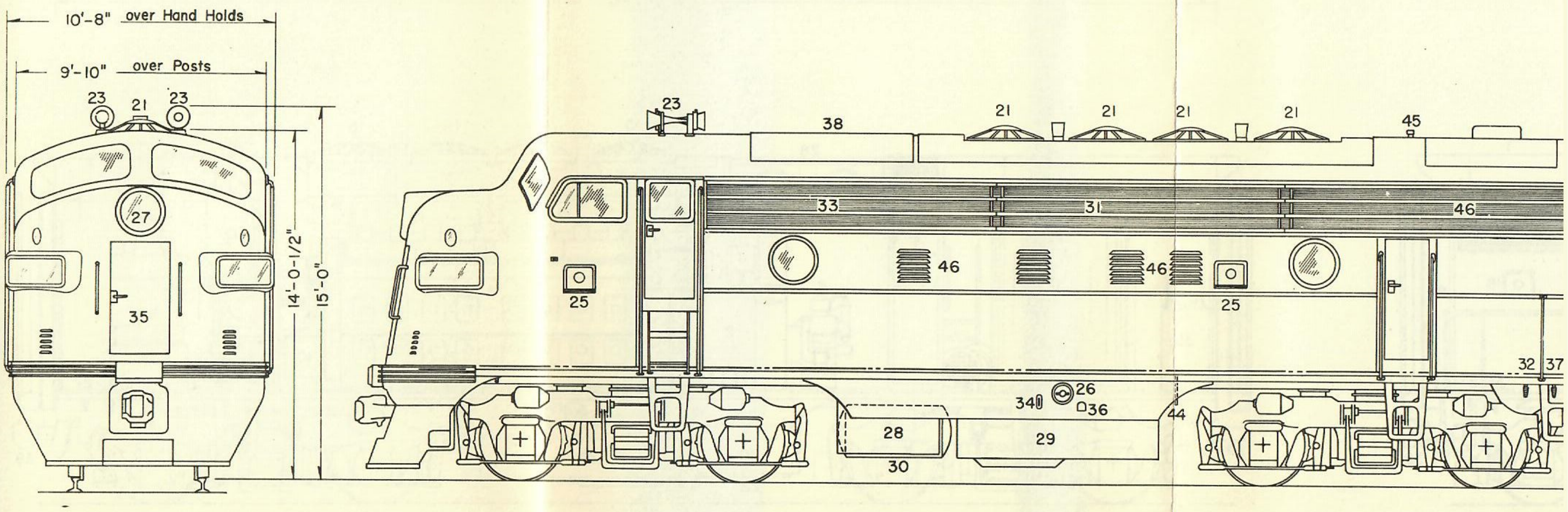
45. Roof Water Filler (Engine)
46. Air Intake Filters for Engine Ro

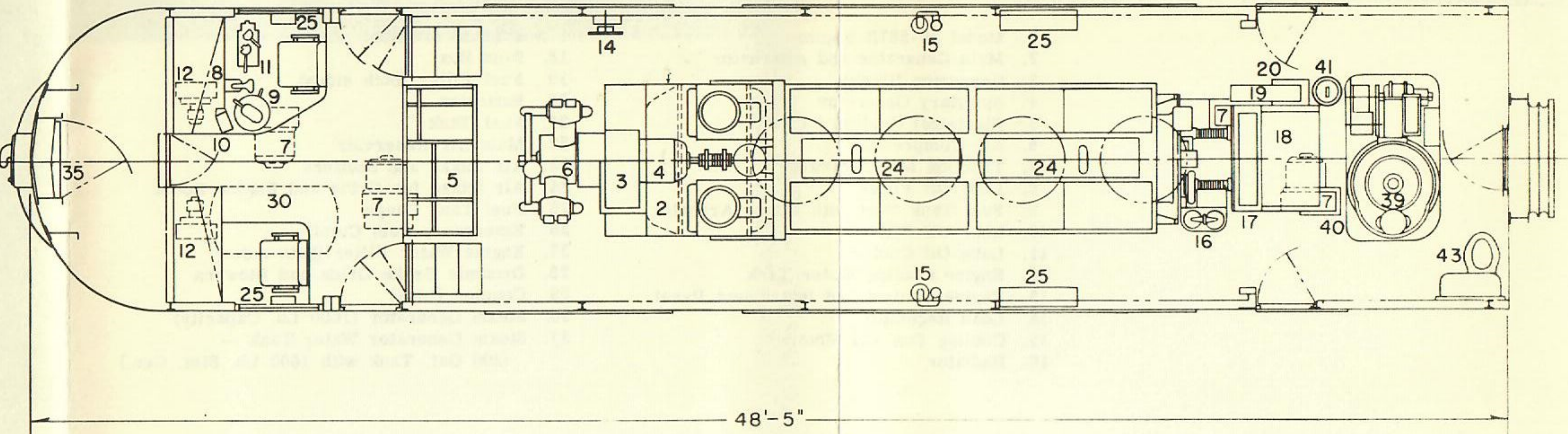


ids

Cutoff
ler (both sides)
rids and Blowers

Water Tank
Water Softener

Drain (left side only).
r (Engine)
s for Engine Room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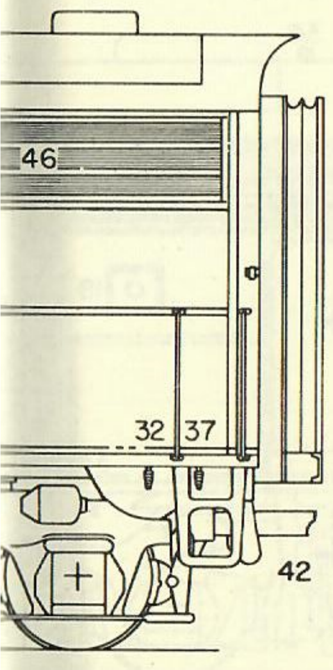
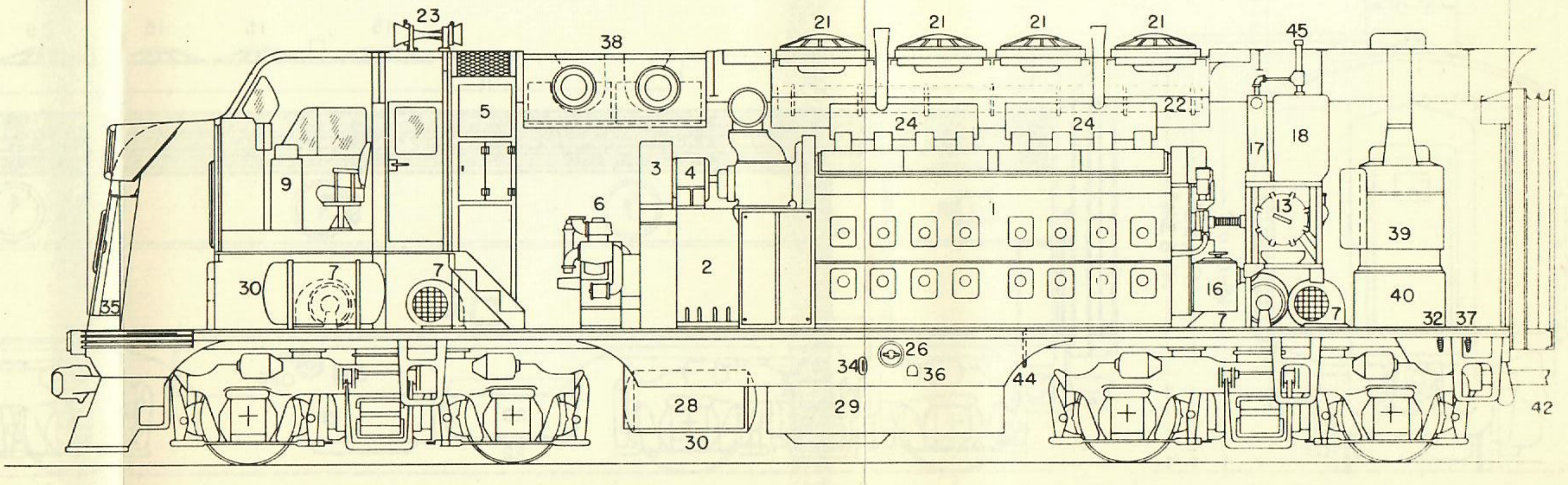
48'-5"

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42

Charts I and II - General Arrangement - "A" Unit, - "B" Unit (On Reverse Side)

1. Model 16-567B Engine
2. Main Generator and Alternator
3. Generator Blower
4. Auxiliary Generator
5. Electrical Control Cabinet
6. Air Compressor
7. Traction Motor Blower
8. Lube Oil Filter
9. Fuel Tank Vent with Flame Arrestor
10. Lube Oil Filler
11. Lube Oil Cooler
12. Engine Cooling Water Tank
13. Engine Control and Instrument Panel
14. Load Regulator
15. Cooling Fan and Motor
16. Radiator
17. Exhaust Manifold
18. Sand Box
19. Fuel Filler (both sides)
20. Batteries
21. Fuel Tank
22. Main Air Reservoir
23. Air Intake and Shutters
24. Air Intake for Grids and Engine Room
25. Fuel Tank Gauge
26. Emergency Fuel Cutoff
27. Engine Water Filler (both sides)
28. Dynamic Brake Grids and Blowers
29. Coupler (Link)
30. Steam Generator (1600 Lb. Capacity)
31. Steam Generator Water Tank — (200 Gal. Tank with 1600 Lb. Stm. Gen.)
32. Steam Generator Water Tank for Large Steam Generators (1200 Gal.)
33. Steam Generator Water Tank Filler — (both sides — 1200 Gal. Tank)
34. Steam Generator Water Tank Filler — (both sides — 200 and 300 Gal. Tanks only)
35. Air Brake Equipment
36. Roof Water Filler (Engine)
37. Engine Sump Oil Drain (left side only)
38. Coupler (Type "E")
39. Hand Brake
40. Steam Generator Water Softener

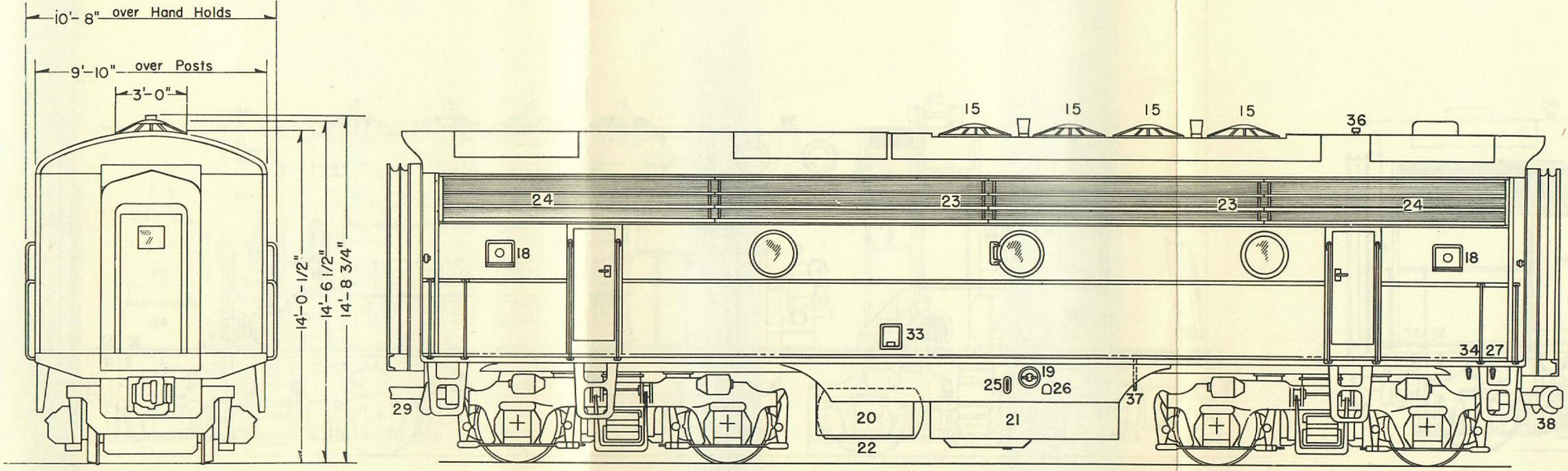

Chart II - General Arrangement "B" Unit

for Large
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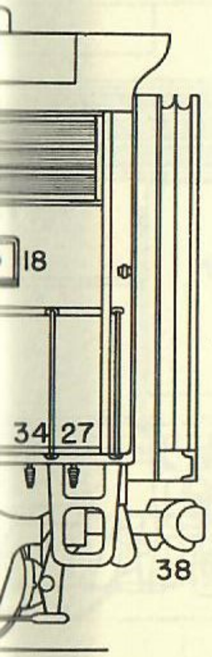
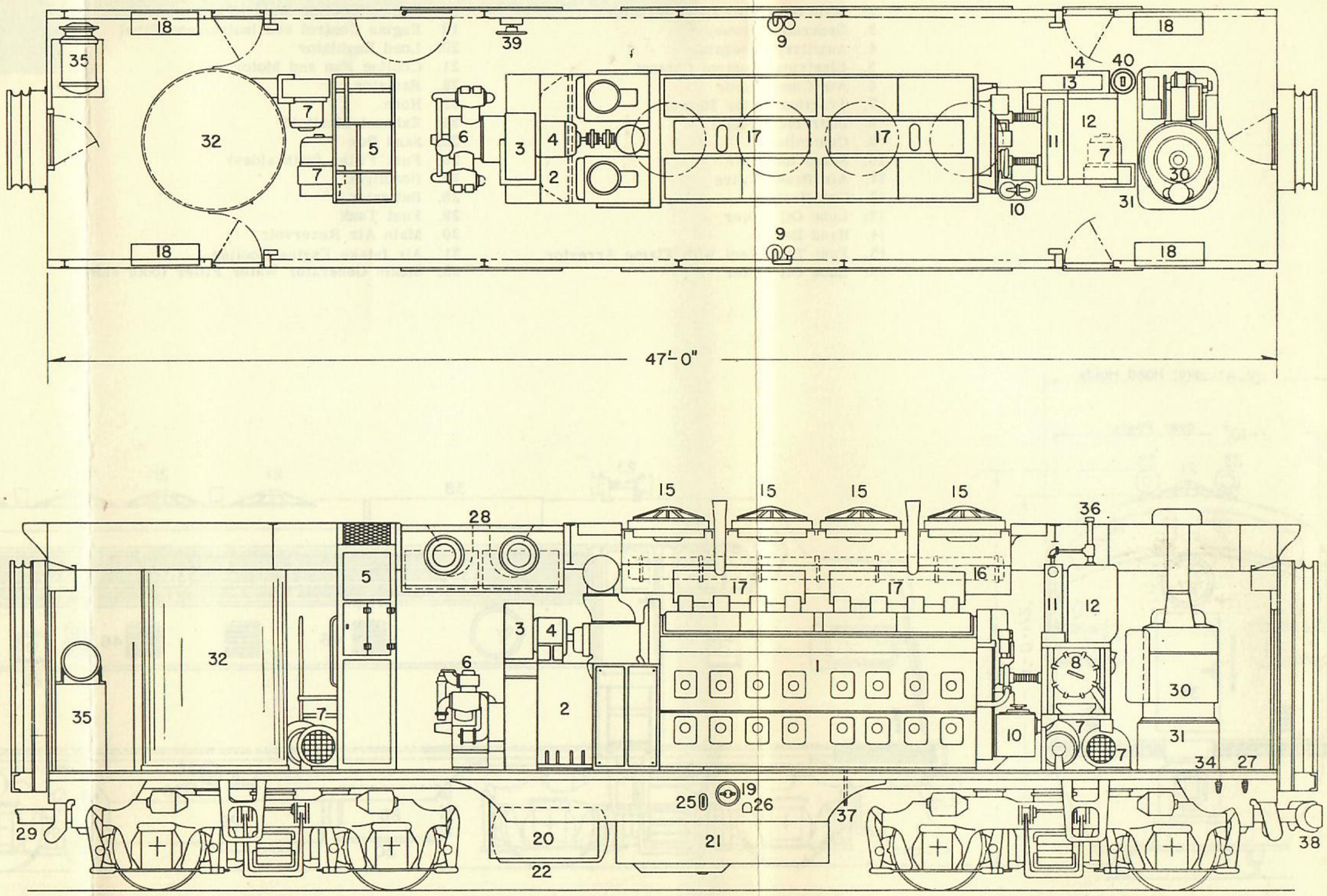
Filler —
k)
Filler —
Gal. Tanks only)

de only)

er





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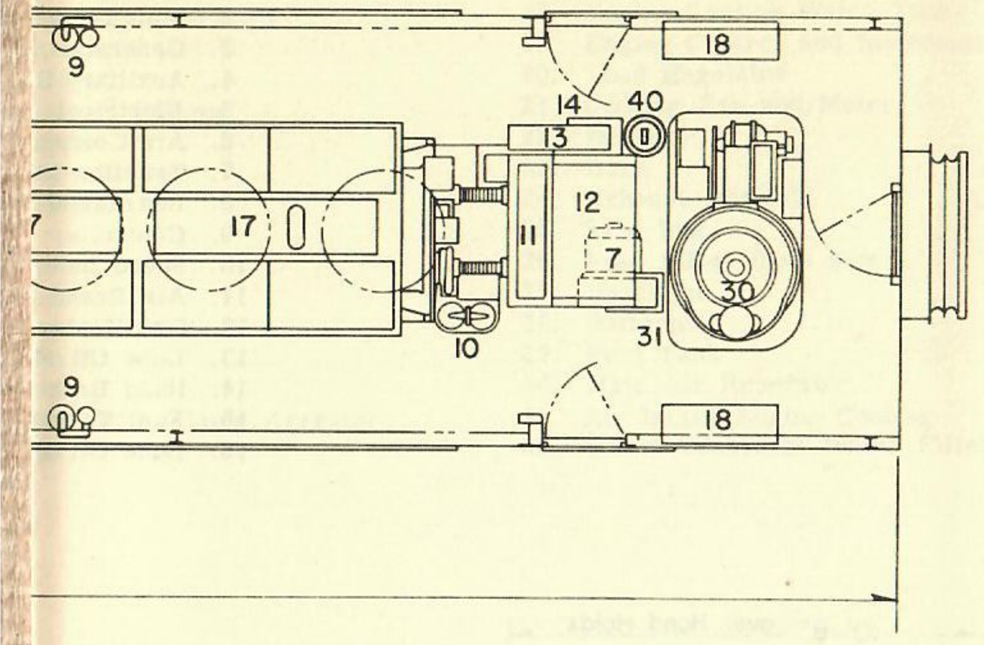
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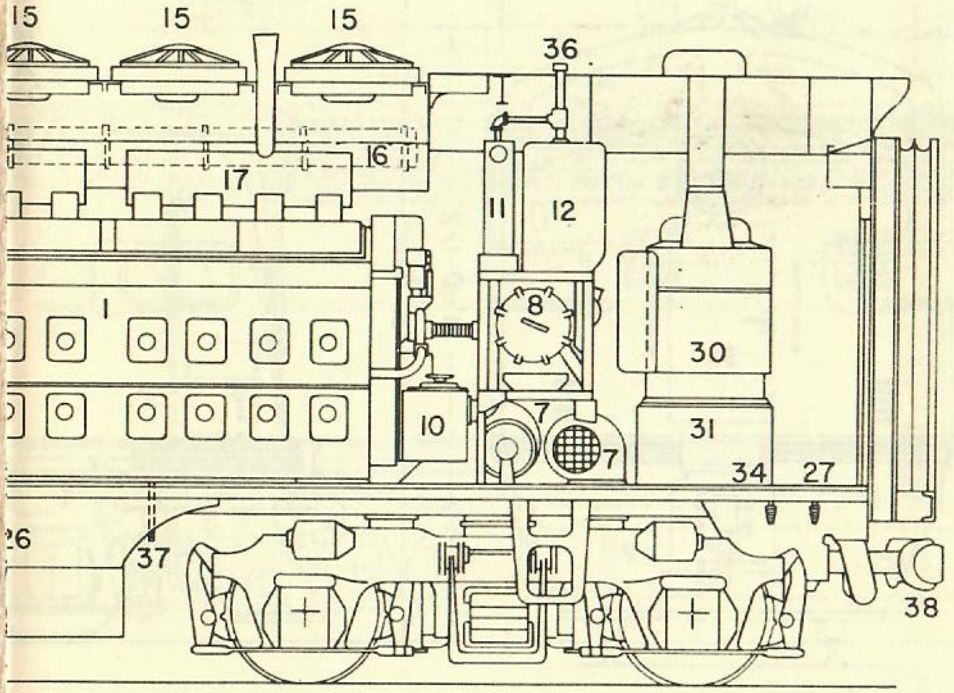
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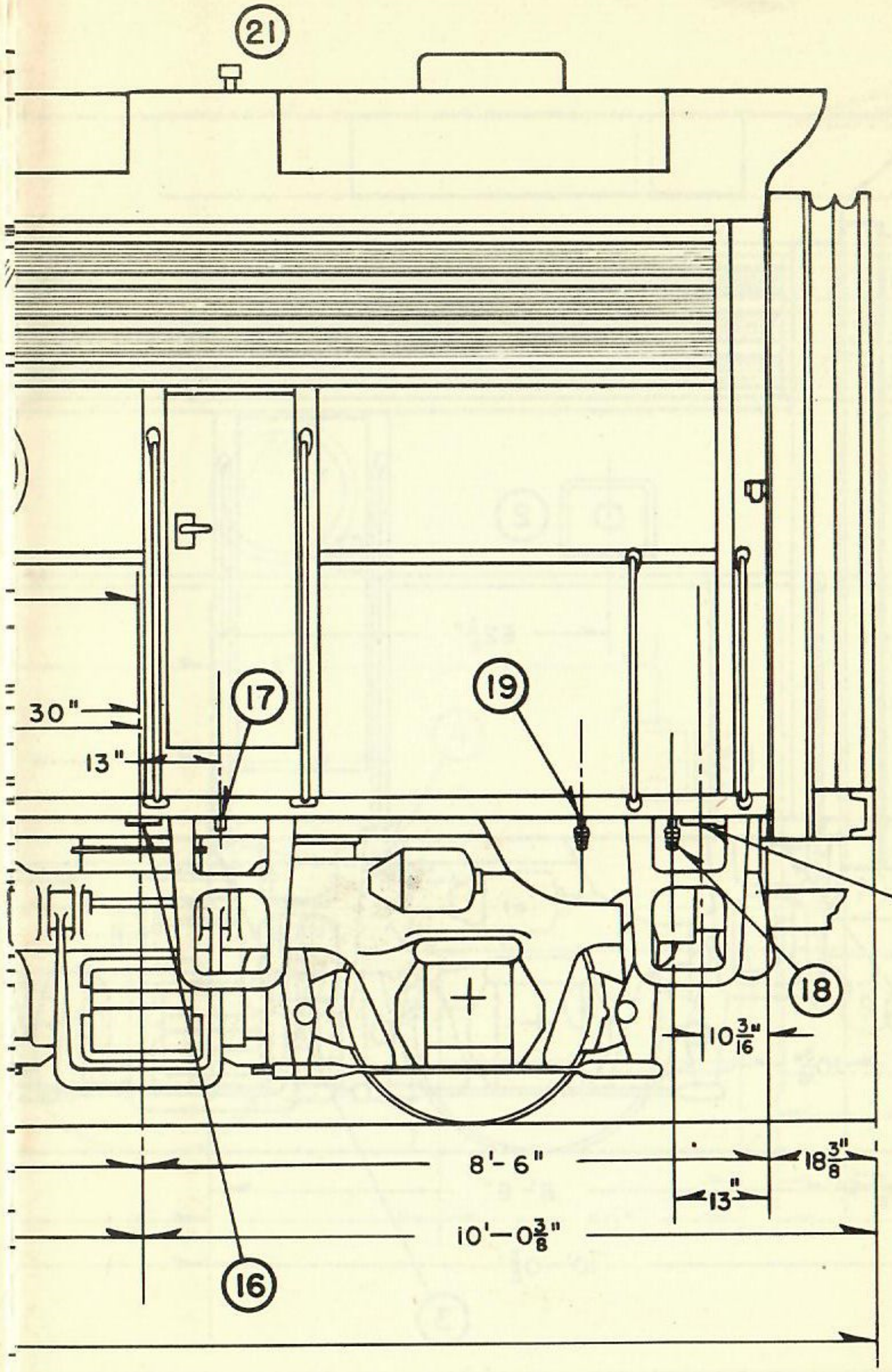
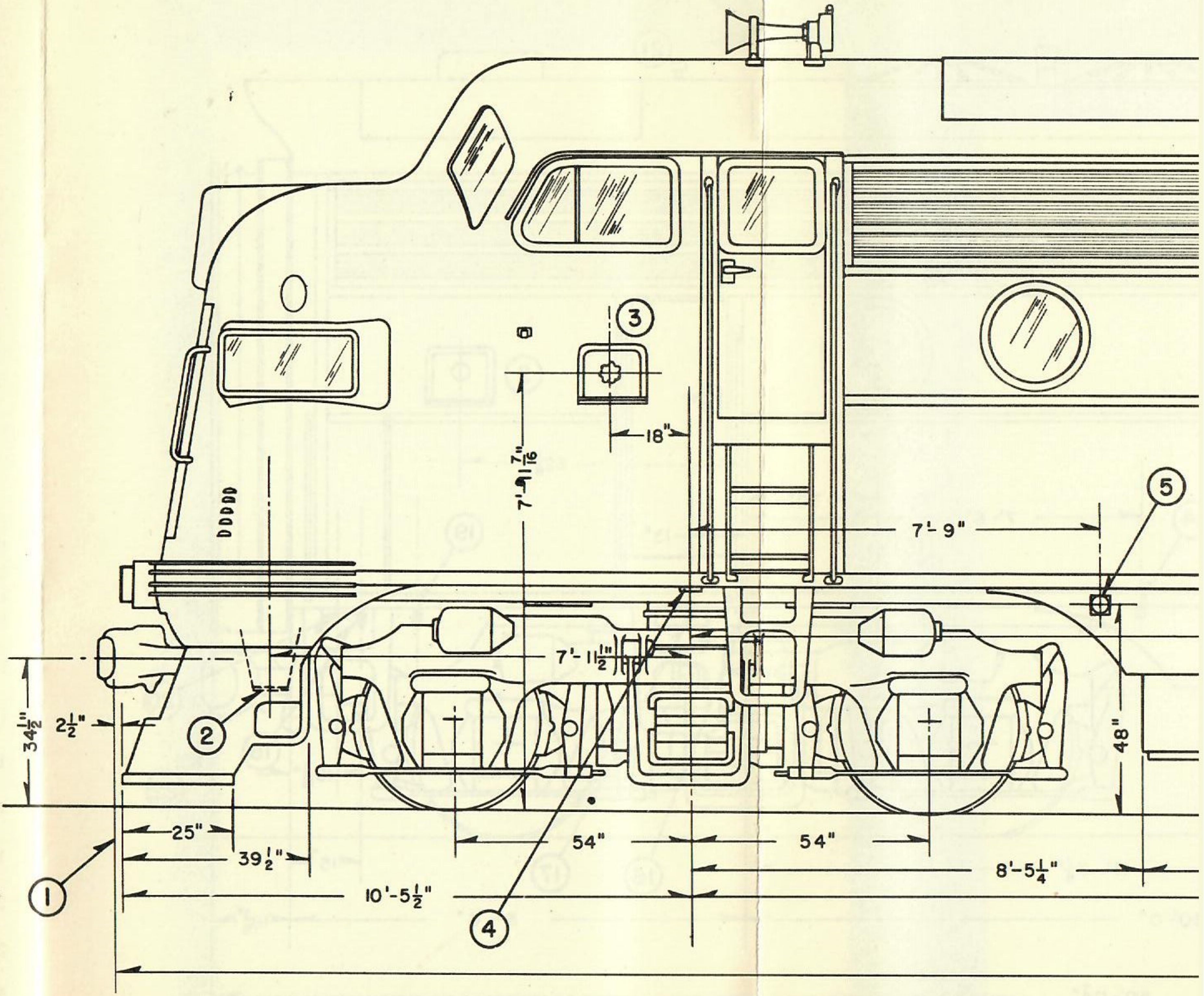
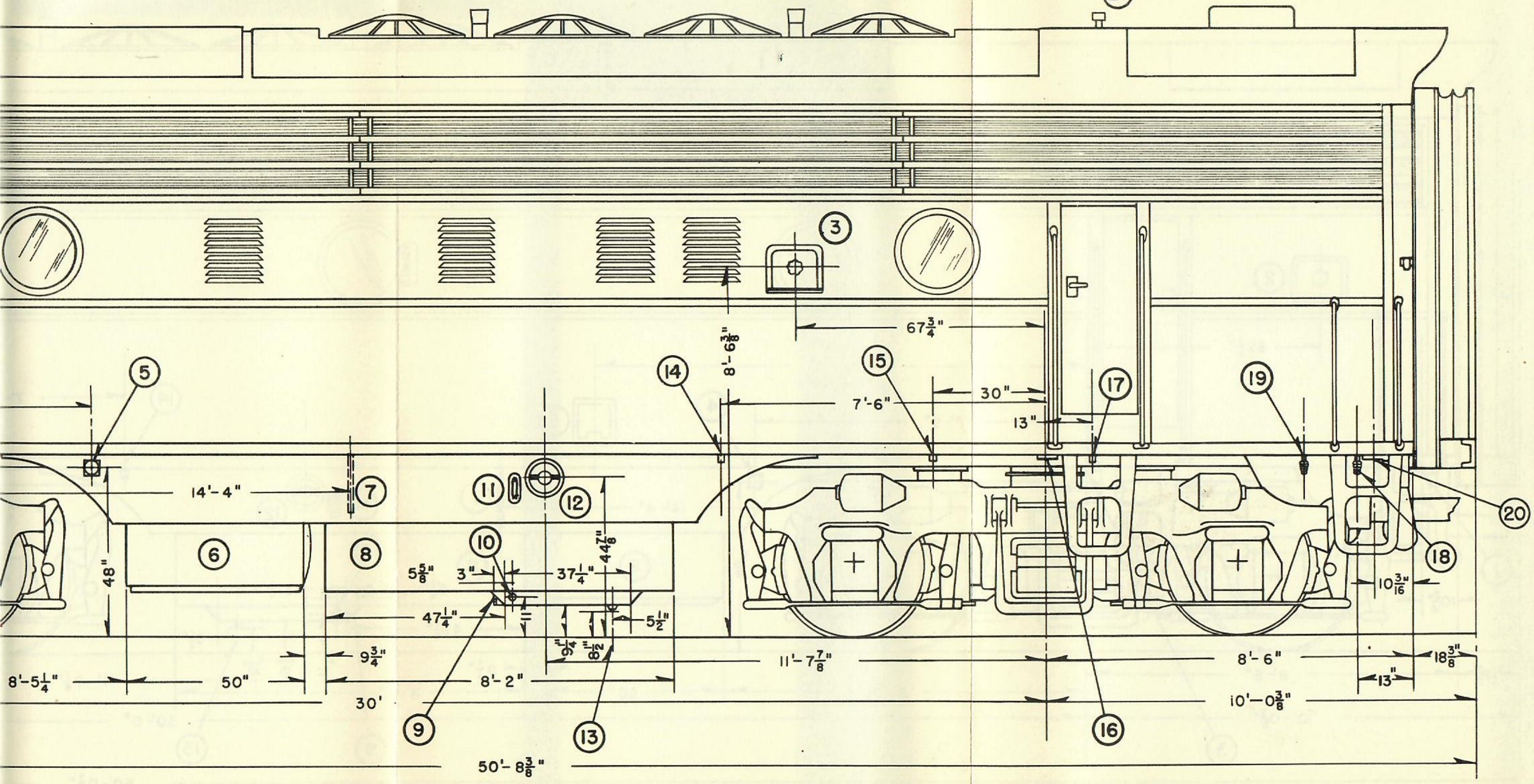

21
30"
13"
17
19
20
18
16
$10\frac{3}{16}$"
8'-6"
13"
$18\frac{3}{8}$"
$10'-0\frac{3}{8}$"

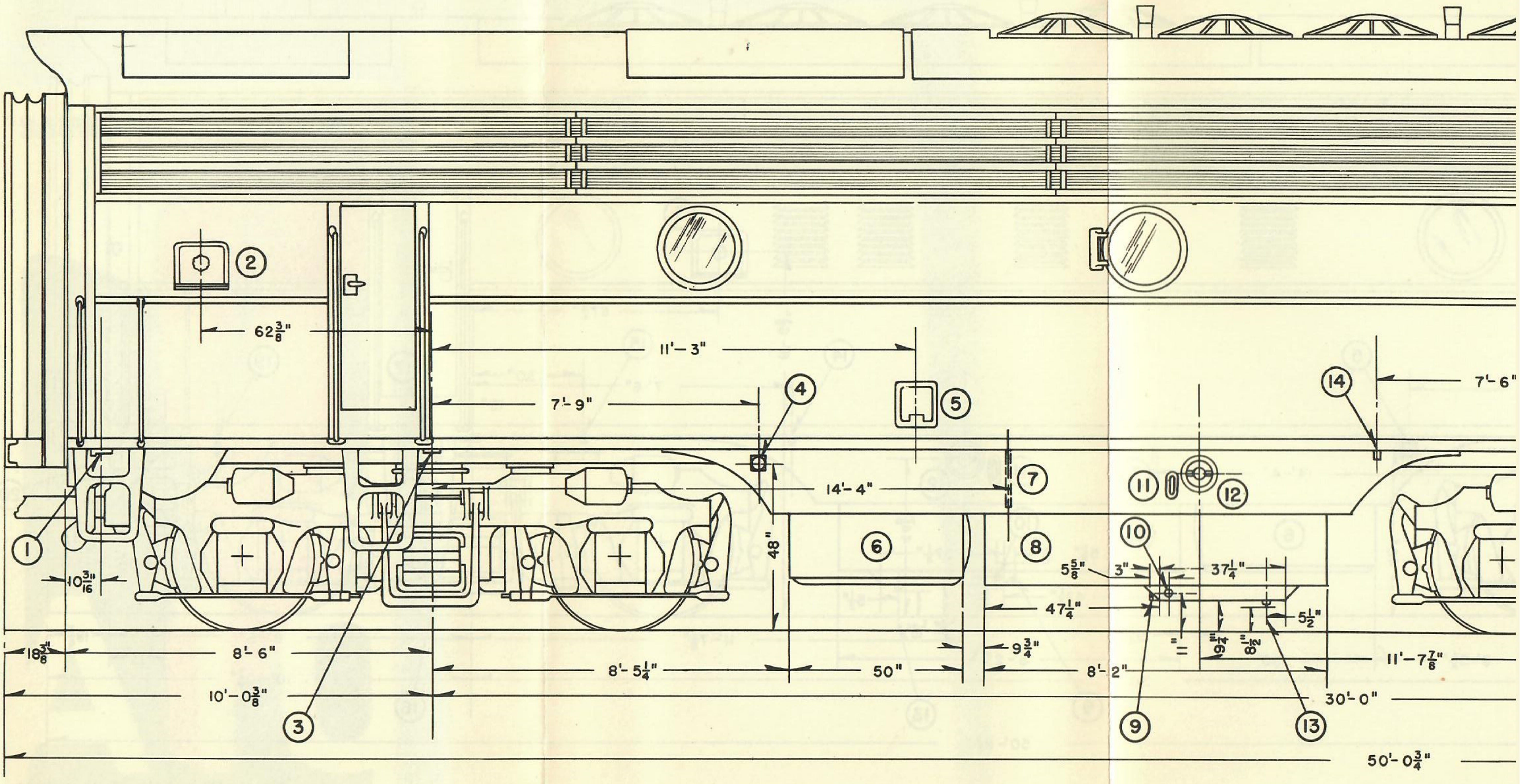
Charts III and IV - Dimensions, Drains and Fillers - "A" Unit, - "B" Unit (On Reverse Side)

1. Pulling Face of Front Coupler.
2. Blocking Pads — both sides under pilot.
3. Sand Box Fillers — two on each side of car.
4. Jacking and Blocking Pads — both sides No. 1 Bolster under carbody.
5. Battery Charging Receptable — left side only.
6. Battery Box — both sides under carbody.
7. Engine Air Box Drain — both sides under carbody, valve at each side of engine under oil pan handhole covers No. 7 and 15.
8. Fuel Tank — under carbody.
9. Fuel Tank Water Drain Valve — both sides in tank
10. Fuel Tank Sump Drain Plug — in tank sump.
11. Fuel Gauge — both sides in side skirt.
12. Fuel Filler — both sides in side skirt. (2-1/2" I.P.S.)
13. Fuel Tank Drain Plug — in bottom of tank sump.
14. Engine Sump Oil Drain — left side, valve and drain under carbody.
15. Engine Water Drain — under carbody, valve inside carbody.
16. Jacking and Blocking Pads — both sides No. 2 bolster under carbody.
17. Engine Oil Strainer Drain — left side under carbody, valve inside carbody.
18. Engine Water Filler — both sides under carbody at rear of car.
19. Steam Generator Water Tank Filler (200 and 300 gal. tanks) — both sides under carbody at rear of car.
20. Blocking Pads — both sides under carbody at rear of car.
21. Engine Roof Water Filler — on roof of car above engine cooling water tank.



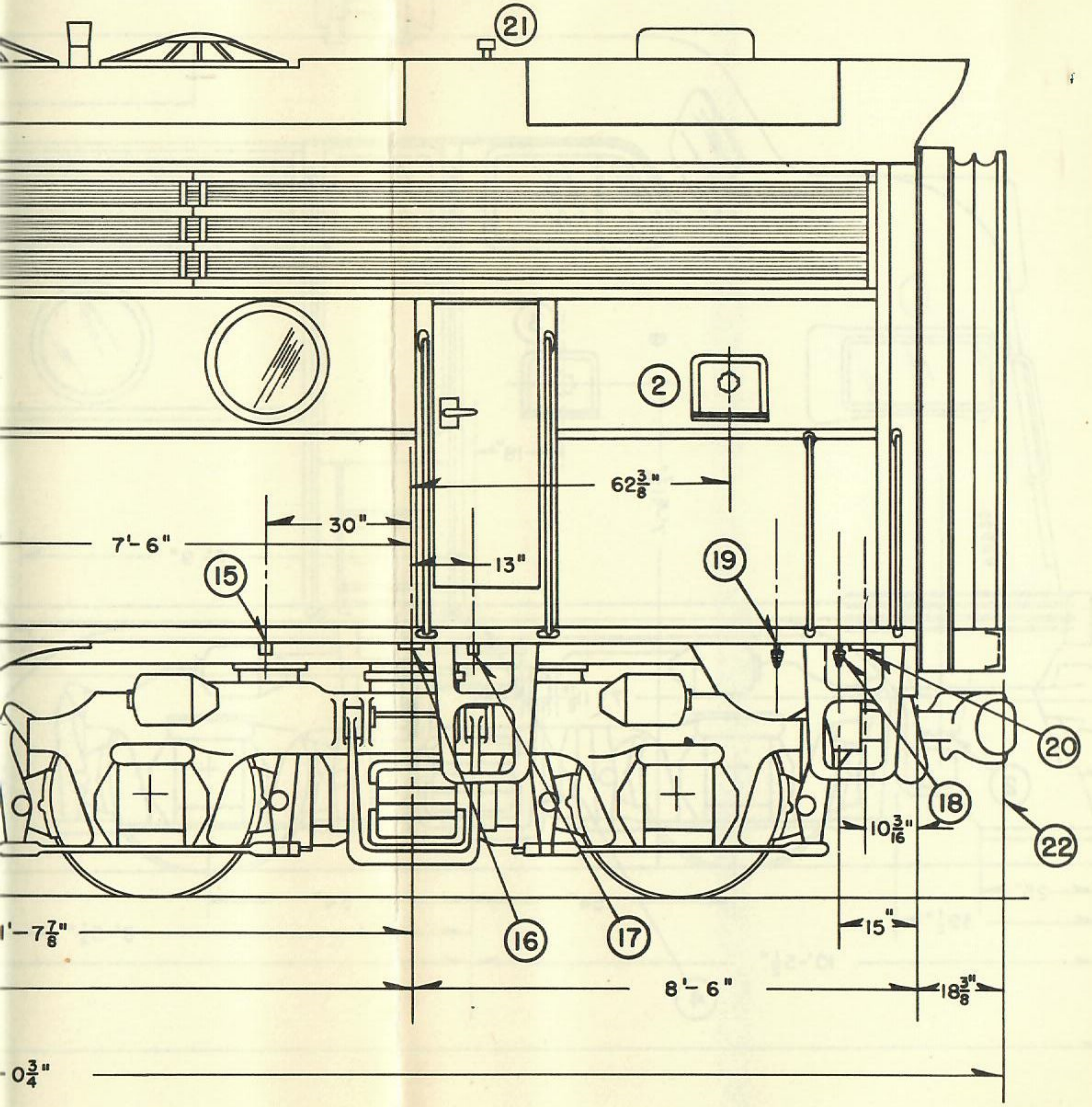

21
3
67 3/4"
8'-6 3/8"
5
14
15
17
19
30"
7'-6"
13"
7
14'-4"
11
12
20
6
8
10
18
48"
44 7/8"
5 5/8"
3"
37 1/4"
10 3/16"
47 1/4"
5 1/2"
9 1/4"
8 1/2"
9 3/4"
11'-7 7/8"
8'-6"
18 3/8"
8'-5 1/4"
50"
8'-2"
13"
30'
10'-0 3/8"
9
13
16
50'-8 3/8"

Charts III and IV - Dimensions, Drains and Fillers - "A" Unit, - "B" Unit (On Reverse Side)



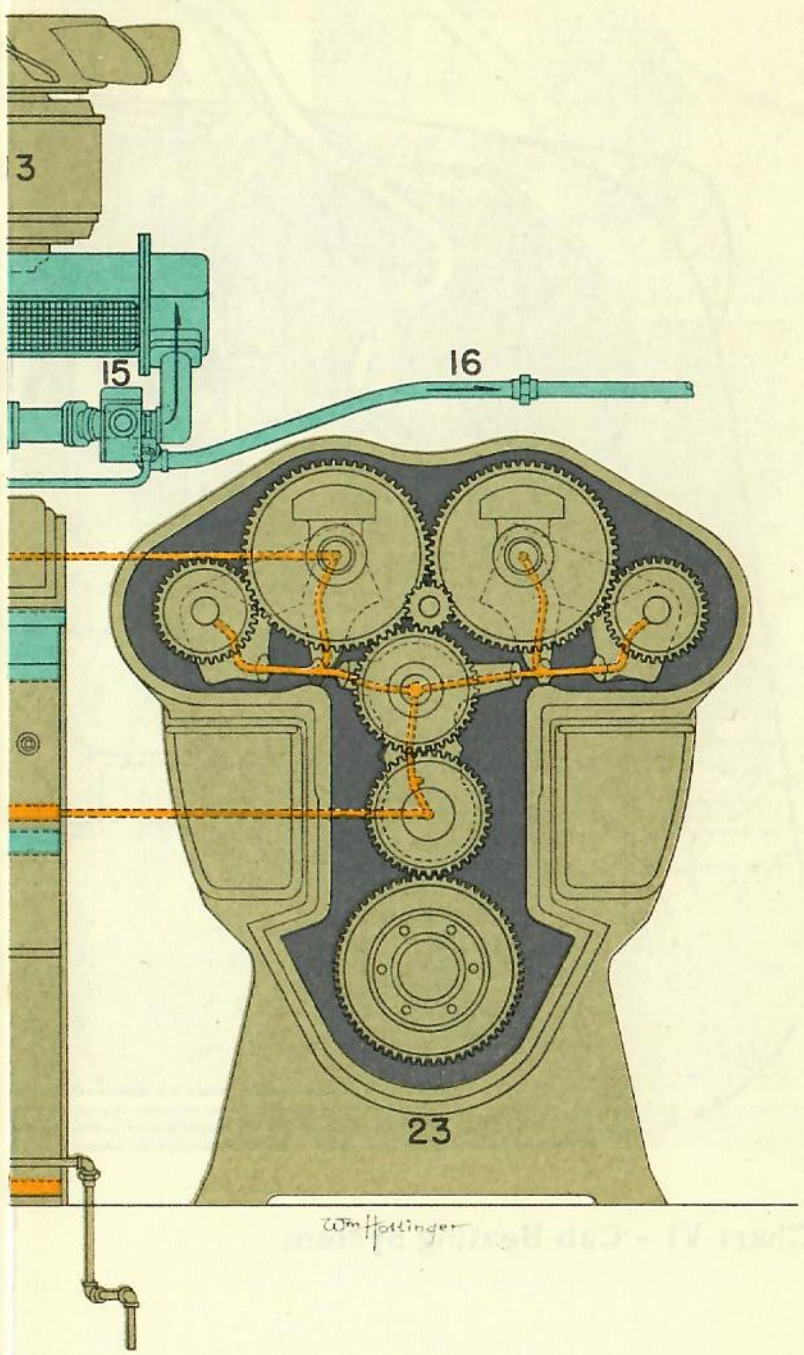
2
62 3/8"
11'-3"
7'-9"
4
5
14
7'-6"
7
11
12
14'-4"
48"
6
8
10
1
10 3/16"
5 5/8"
3"
37 1/4"
47 1/4"
5 1/2"
9 1/4"
8 1/2"
18 3/8"
8'-6"
9 3/4"
8'-5 1/4"
50"
8'-2"
11'-7 7/8"
10'-0 3/8"
30'-0"
3
9
13
50'-0 3/4"

Chart IV - Dimensions, Drains and Fillers - "B" Unit



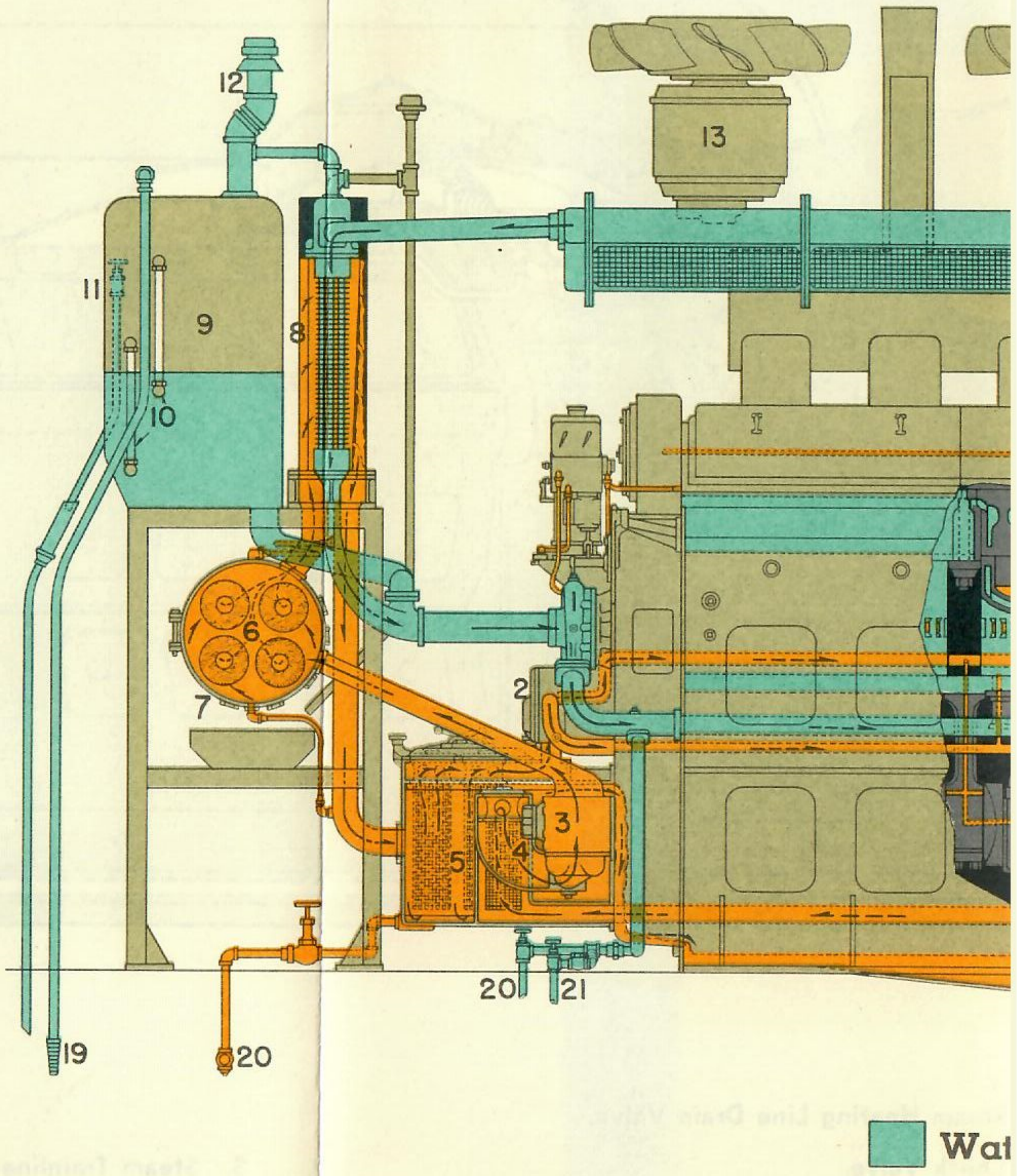
1. Blocking Pads — both sides under carbody at front of car.
2. Sand Box Fillers — two on each side of car.
3. Jacking and Blocking Pads — both sides No. 1 bolster under carbody.
4. Battery Charging Receptacle — left side only.
5. Steam Generator Water Tank Filler (1200 gal. tank) — both sides — 2-1/2" National Fire Hose Connection.
6. Battery Box — both sides under carbody.
7. Engine Air Box Drain — both sides under carbody, valves at each side of engine under oil pan handhole covers No. 7 and 15.
8. Fuel Tank — under carbody.
9. Fuel Tank Water Drain Valve — both sides in tank sump.
10. Fuel Tank Sump Drain Plug — in tank sump.
11. Fuel Gauge — both sides in side skirt.
12. Fuel Filler — both sides in side skirt. (2-1/2" I.P.S.)
13. Fuel Tank Drain Plug — in bottom of tank sump.
14. Engine Sump Oil Drain — left side, valve and drain under carbody.
15. Engine Water Drain — under carbody, valve inside carbody.
16. Jacking and Blocking Pads — both sides No. 2 bolster under carbody.
17. Engine Oil Strainer Drain — left side under carbody valve inside carbody.
18. Engine Water Filler — both sides under carbody at rear of car.
19. Steam Generator Water Tank Filler (200 and 300 gal. tanks) — both sides under carbody at rear of car.
20. Blocking Pads -- both sides under carbody at rear of car.
21. Engine Roof Water Filler — on roof of car above engine cooling water tank.
22. Pulling Face of Rear Coupler.

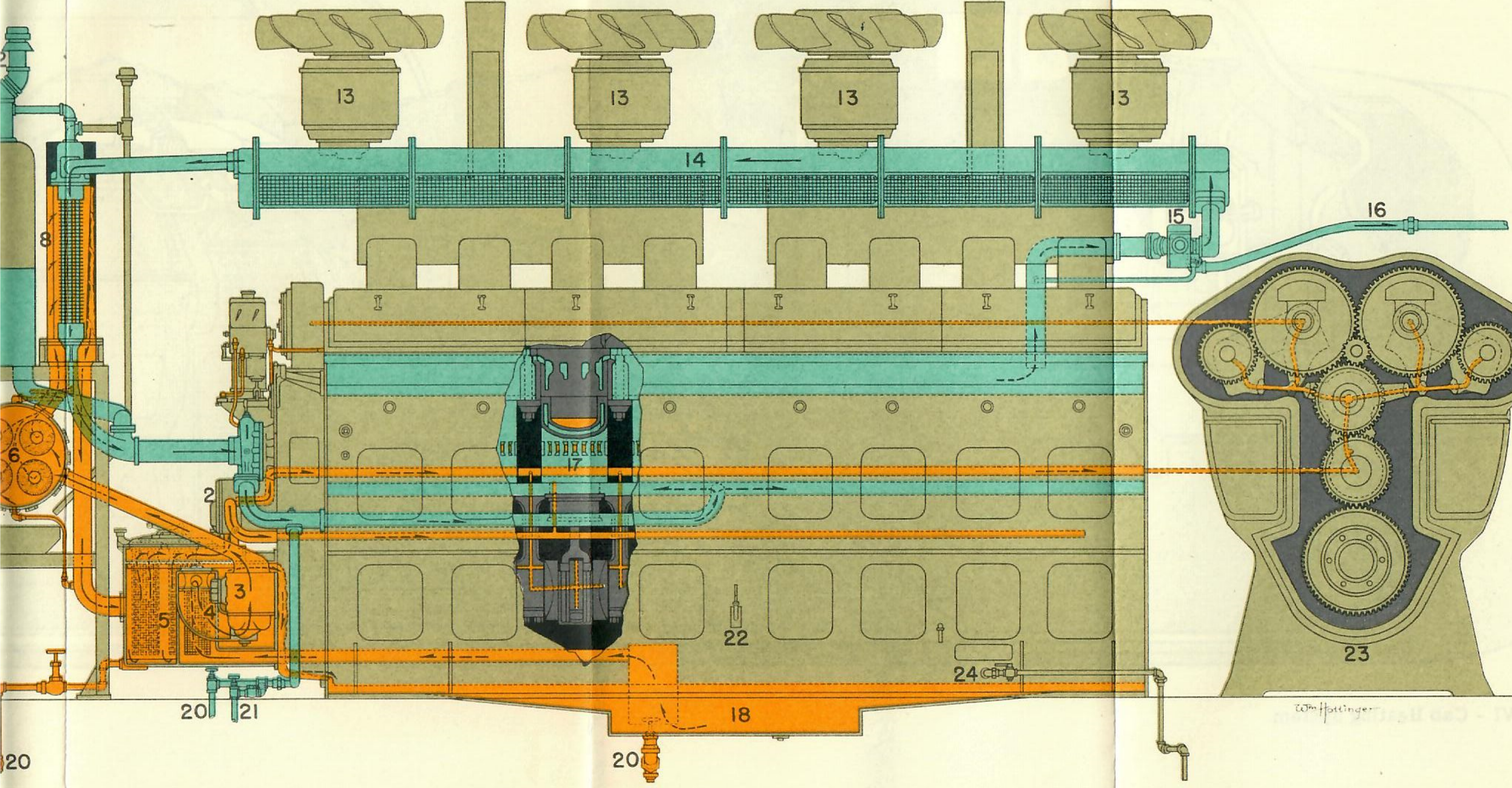
1. Blocking Pads — both sides under carbody at front of car.
2. Sand Box Fillers — two on each side of car.
3. Jacking and Blocking Pads — both sides No. 1 bolster under carbody.
4. Battery Charging Receptacle — left side only.
5. Steam Generator Water Tank Filler (1200 gal. tank) — both sides — 2-1/2" National Fire Hose Connection.
6. Battery Box — both sides under carbody.
7. Engine Air Box Drain — both sides under carbody, valves at each side of engine under oil pan handhole covers No. 7 and 15.
8. Fuel Tank — under carbody.
9. Fuel Tank Water Drain Valve — both sides in tank sump.
10. Fuel Tank Sump Drain Plug — in tank sump.
11. Fuel Gauge — both sides in side skirt.
12. Fuel Filler — both sides in side skirt. (2-1/2" I.P.S.)
13. Fuel Tank Drain Plug — in bottom of tank sump.
14. Engine Sump Oil Drain — left side, valve and drain under carbody.
15. Engine Water Drain — under carbody, valve inside carbody.
16. Jacking and Blocking Pads — both sides No. 2 bolster under carbody.
17. Engine Oil Strainer Drain — left side under carbody valve inside carbody.
18. Engine Water Filler — both sides under carbody at rear of car.
19. Steam Generator Water Tank Filler (200 and 300 gal. tanks) — both sides under carbody at rear of car.
20. Blocking Pads -- both sides under carbody at rear of car.
21. Engine Roof Water Filler — on roof of car above engine cooling water tank.
22. Pulling Face of Rear Coupler.



Charts V and VI - Schematic of Cooling and Lube Oil System, - Cab Heating System (On Reverse Side)

1. Water Pump
2. Lubricating Oil Pump
3. Scavenging Oil Pump
4. Sump Oil Strainer
5. Lube Oil Strainers
6. Lube Oil Filter
7. Lube Oil Relief Valves
8. Lube Oil Cooler
9. Cooling Water Tank
10. Water Level Gauges
11. "G" Valve
12. Roof Filler
13. Cooling Fans
14. Radiator
15. Thermostat Switch
16. To Cab Heater
17. Cylinder Liner
18. Engine Sump
19. Side Filler
20. Drains
21. Steam Admission Line
22. Bayonet Gauge
23. Camshaft Drive Gear Train
24. Air Box Drain

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20
20
Wm Hollinger

🟩 **Water** 🟧 **Lubricating Oil**

**Charts V and VI - Schematic
of Cooling and Lube Oil System, -
Cab Heating System (On Reverse Side)**

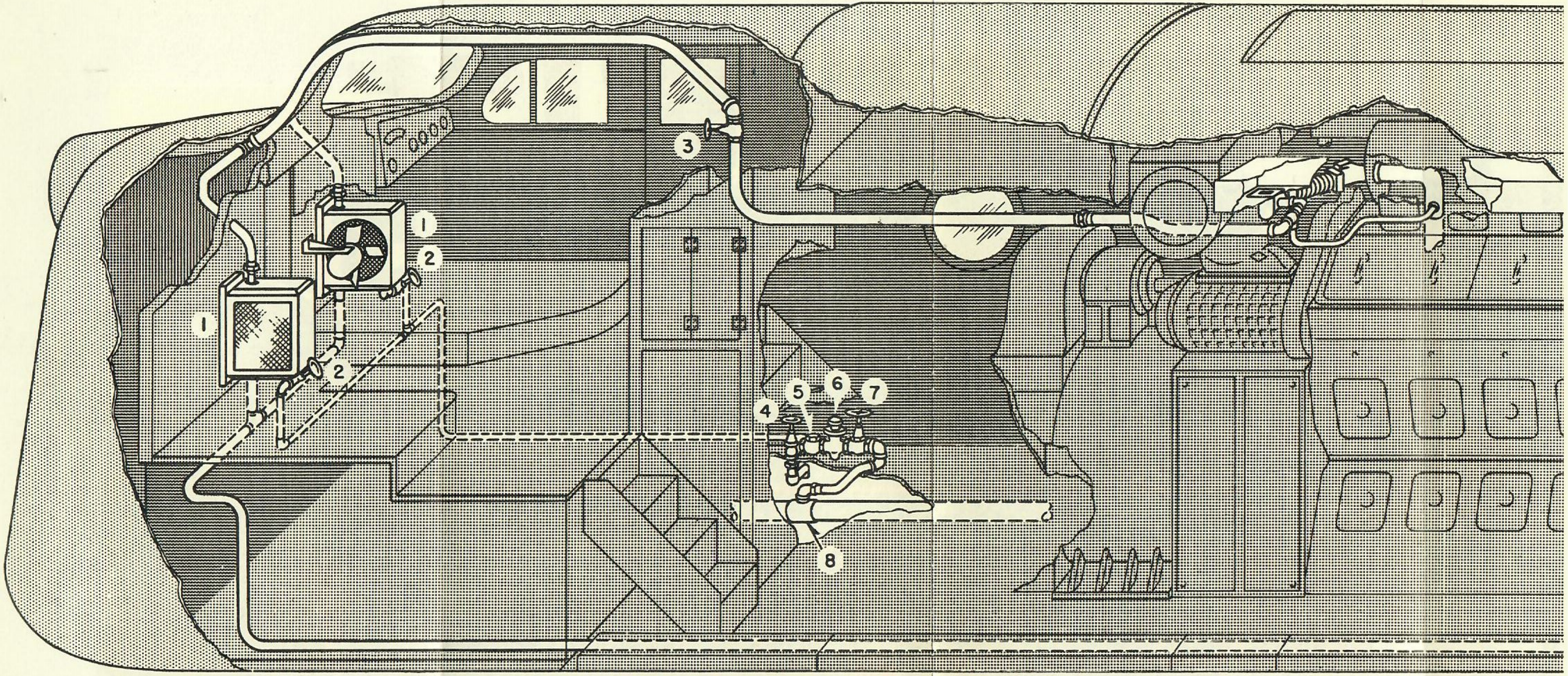
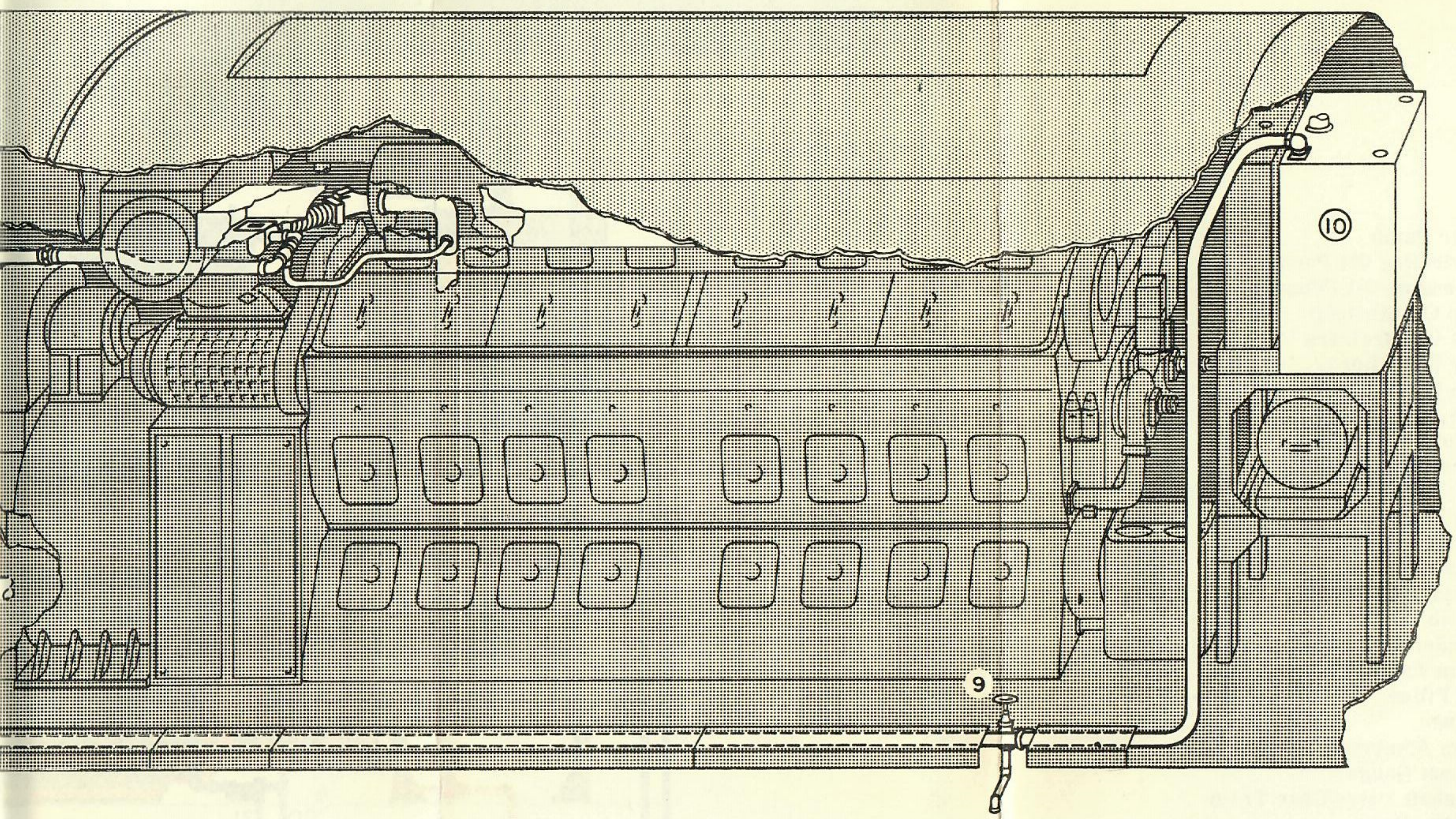


Chart VI - Cab Heating System

1. Cab Heaters.
2. Cab Heater Steam Valves.
3. Cab Heater Valve.

4. Steam Heating Line Drain Valve.
5. Check Valve.
6. Steam Pressure Reducing Valve.
7. Steam Admission Valve.

8. Steam
9. Cab H
10. Engine



eating Line Drain Valve.

lve.

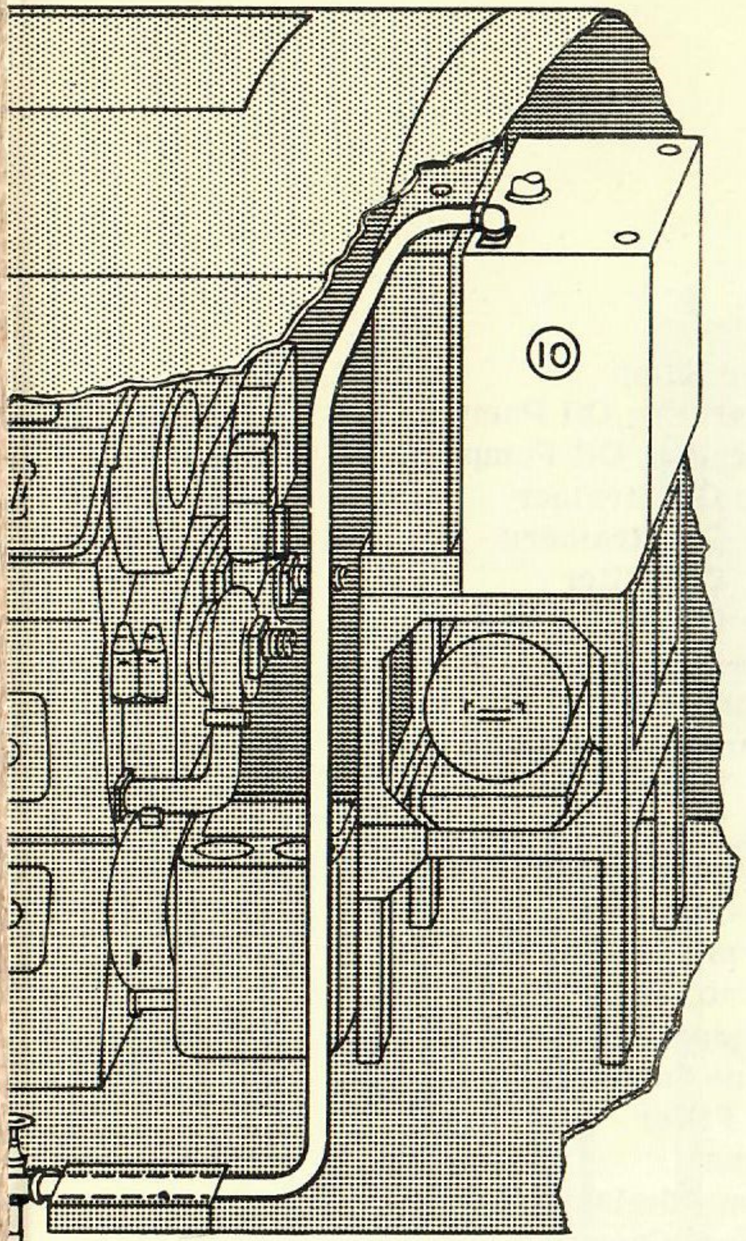
essure Reducing Valve.

dmission Valve.

8. Steam Trainline Connection.

9. Cab Heater Drain Valve.

10. Engine Cooling Water Tank.



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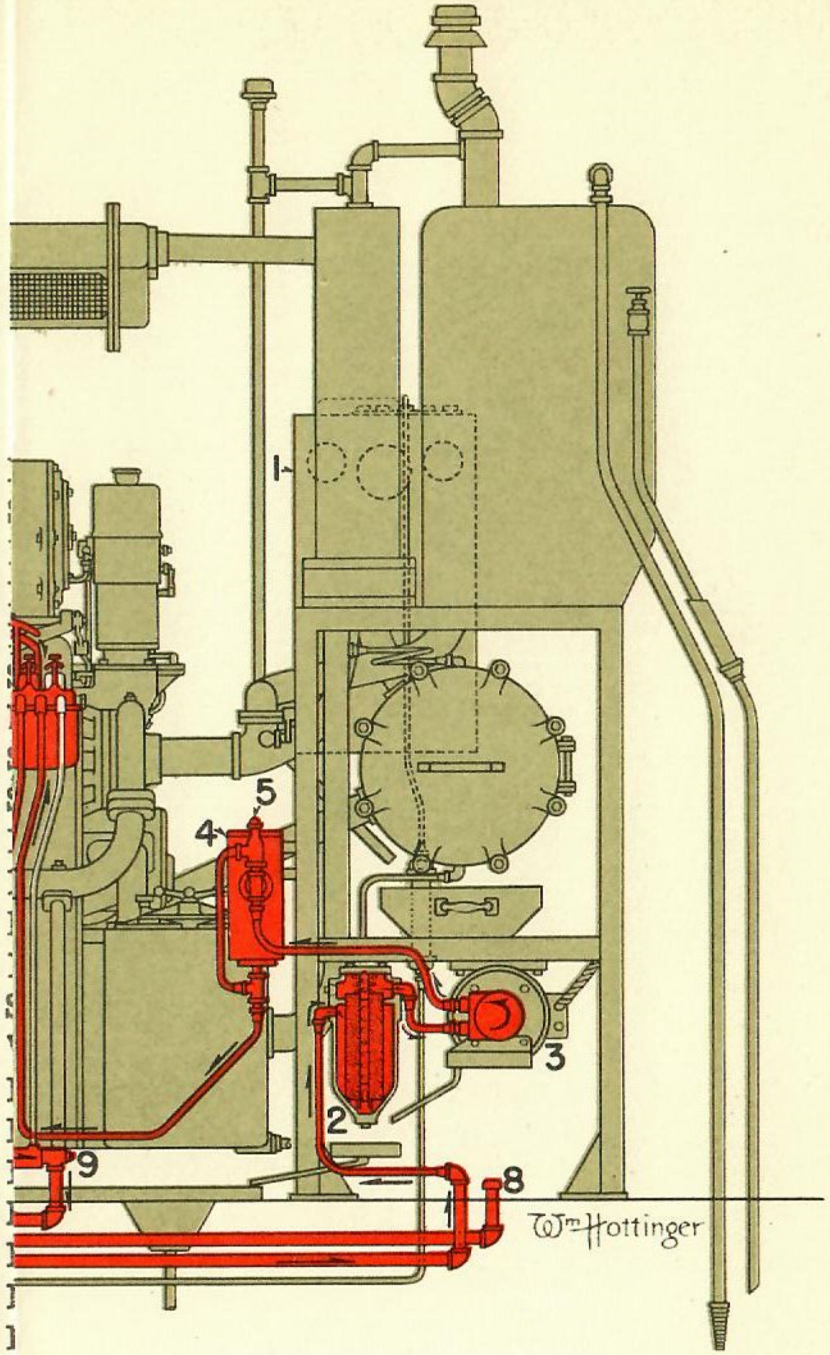
1
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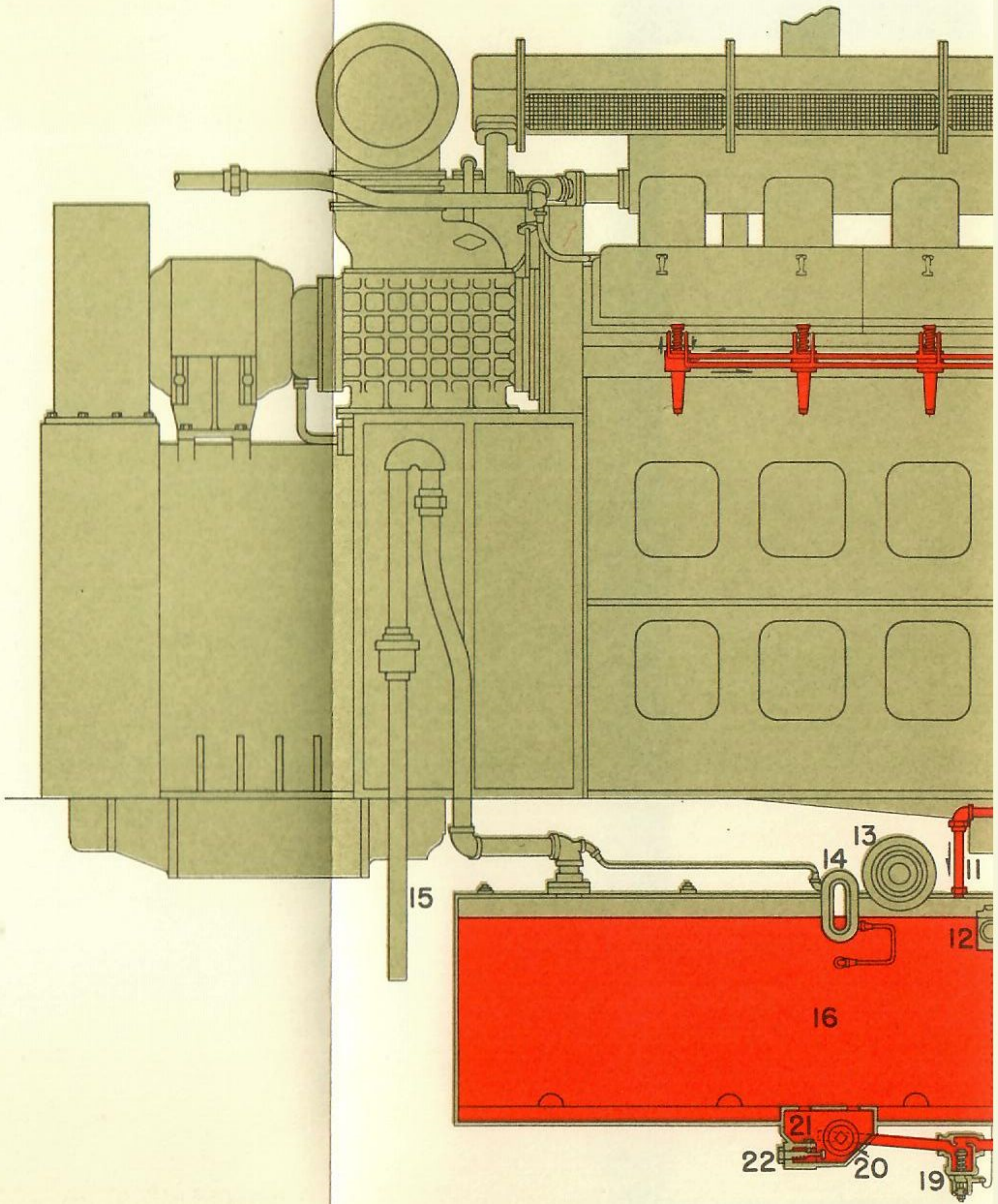
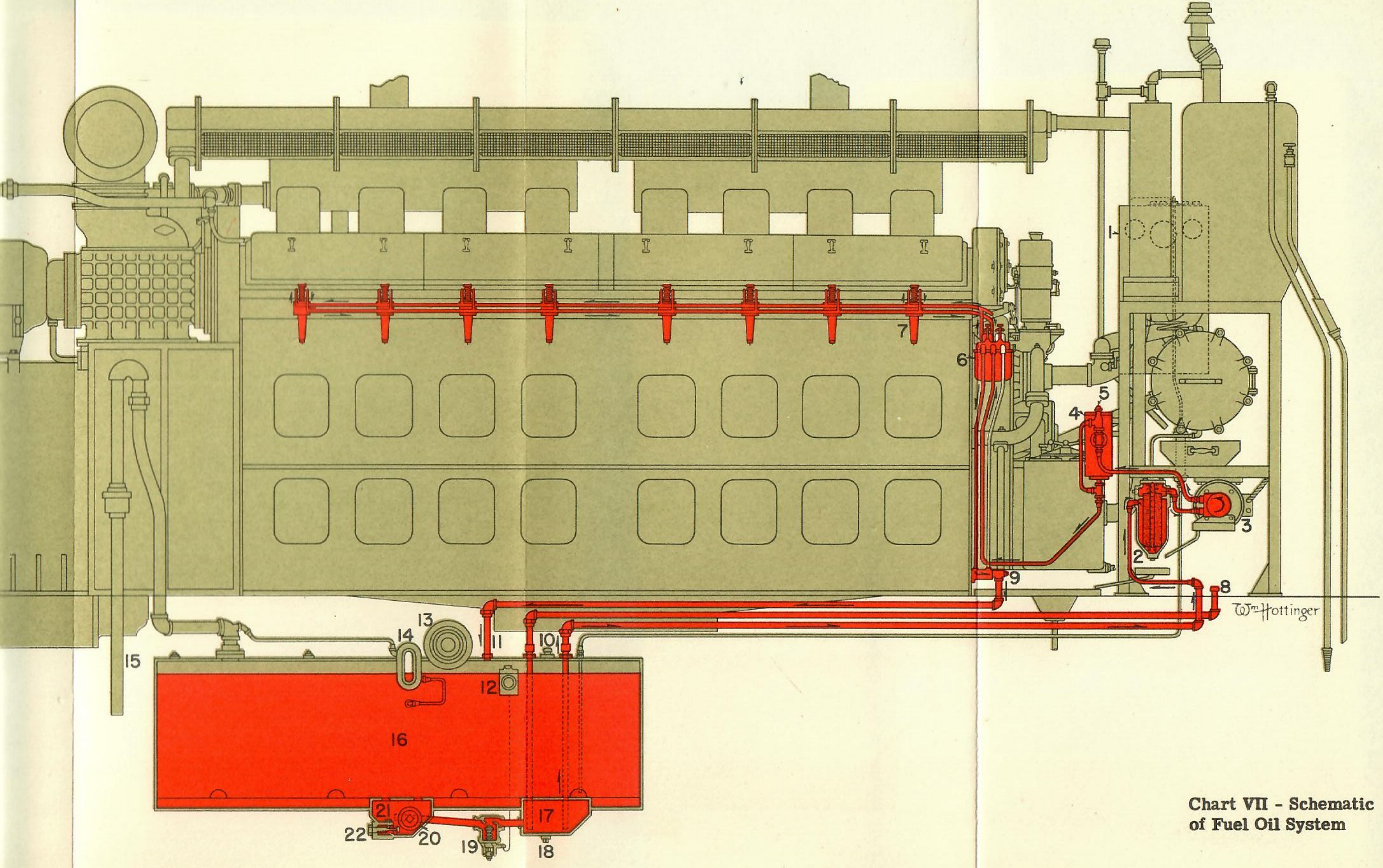
8
9
Wm Hottinger

Chart VII - Schematic of Fuel Oil System

1. Engine Control and Instrument Panel
2. Suction Filter
3. Fuel Pump and Motor
4. Fulflo Filter
5. Filter By-Pass Relief Valve
6. Sintered Bronze Filter and Sight Glass Assembly
7. Injector
8. Steam Generator Fuel Supply
9. Steam Generator Fuel Return
10. Fuel Supply to Engine
11. Fuel Return from Engine
12. Emergency Fuel Cutoff Pull Ring
13. Fuel Filler
14. Sight Gauge
15. Vent and Flame Arrestor
16. Fuel Tank
17. Fuel Supply Sump
18. Fuel Drain Plug
19. Emergency Fuel Cutoff Valve
20. Fuel Drain Plug
21. Fuel Tank Sump
22. Fuel Tank Water Drain Plug

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21
22
Wm Hottinger

Chart VII - Schematic of Fuel Oil System

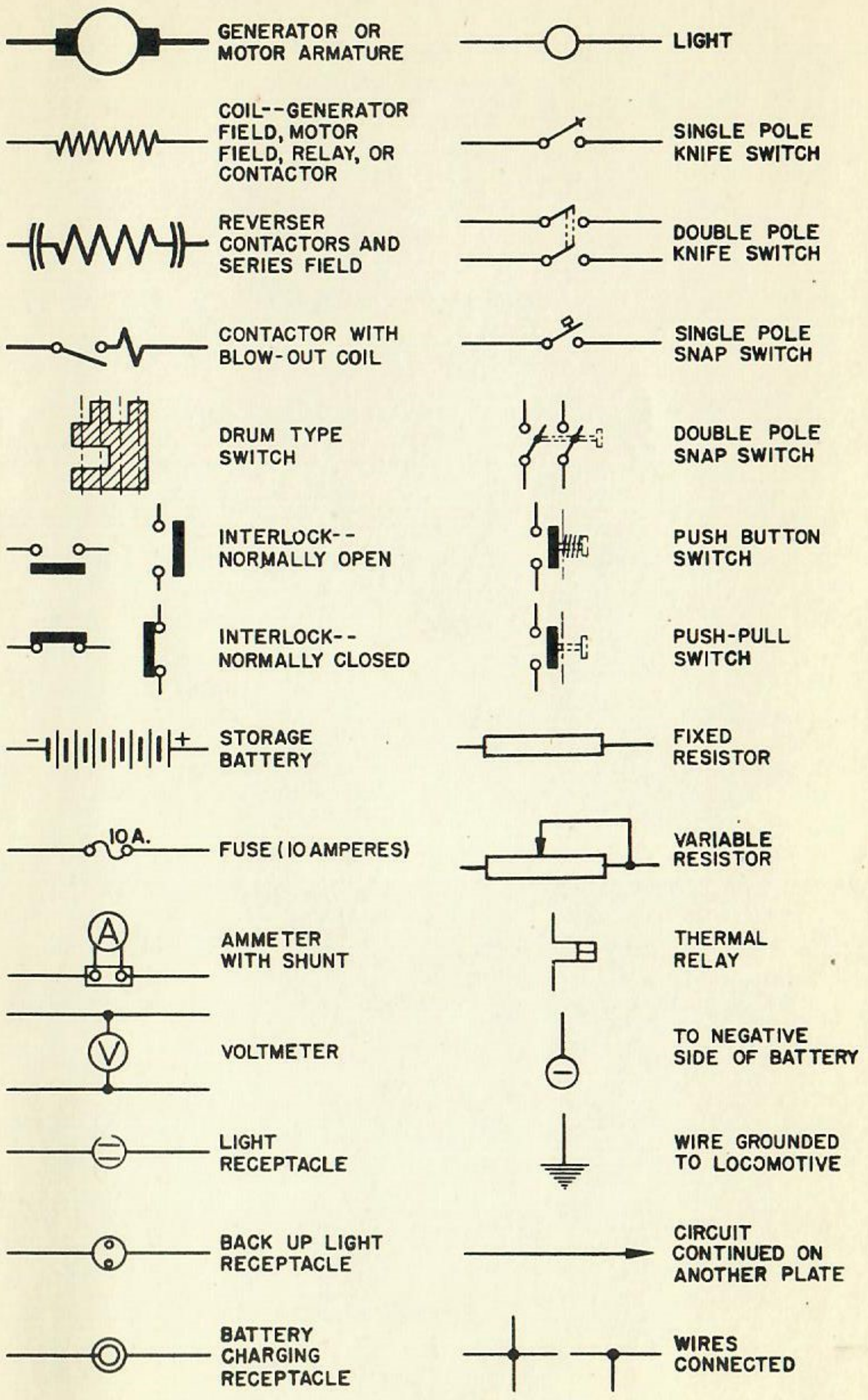

GENERATOR OR MOTOR ARMATURE
LIGHT
COIL--GENERATOR FIELD, MOTOR FIELD, RELAY, OR CONTACTOR
SINGLE POLE KNIFE SWITCH
REVERSER CONTACTORS AND SERIES FIELD
DOUBLE POLE KNIFE SWITCH
CONTACTOR WITH BLOW-OUT COIL
SINGLE POLE SNAP SWITCH
DRUM TYPE SWITCH
DOUBLE POLE SNAP SWITCH
INTERLOCK--NORMALLY OPEN
PUSH BUTTON SWITCH
INTERLOCK--NORMALLY CLOSED
PUSH-PULL SWITCH
−
+
STORAGE BATTERY
FIXED RESISTOR
10 A.
FUSE (10 AMPERES)
VARIABLE RESISTOR
A
AMMETER WITH SHUNT
THERMAL RELAY
V
VOLTMETER
TO NEGATIVE SIDE OF BATTERY
LIGHT RECEPTACLE
WIRE GROUNDED TO LOCOMOTIVE
BACK UP LIGHT RECEPTACLE
CIRCUIT CONTINUED ON ANOTHER PLATE
BATTERY CHARGING RECEPTACLE
WIRES CONNECTED

Chart VIII

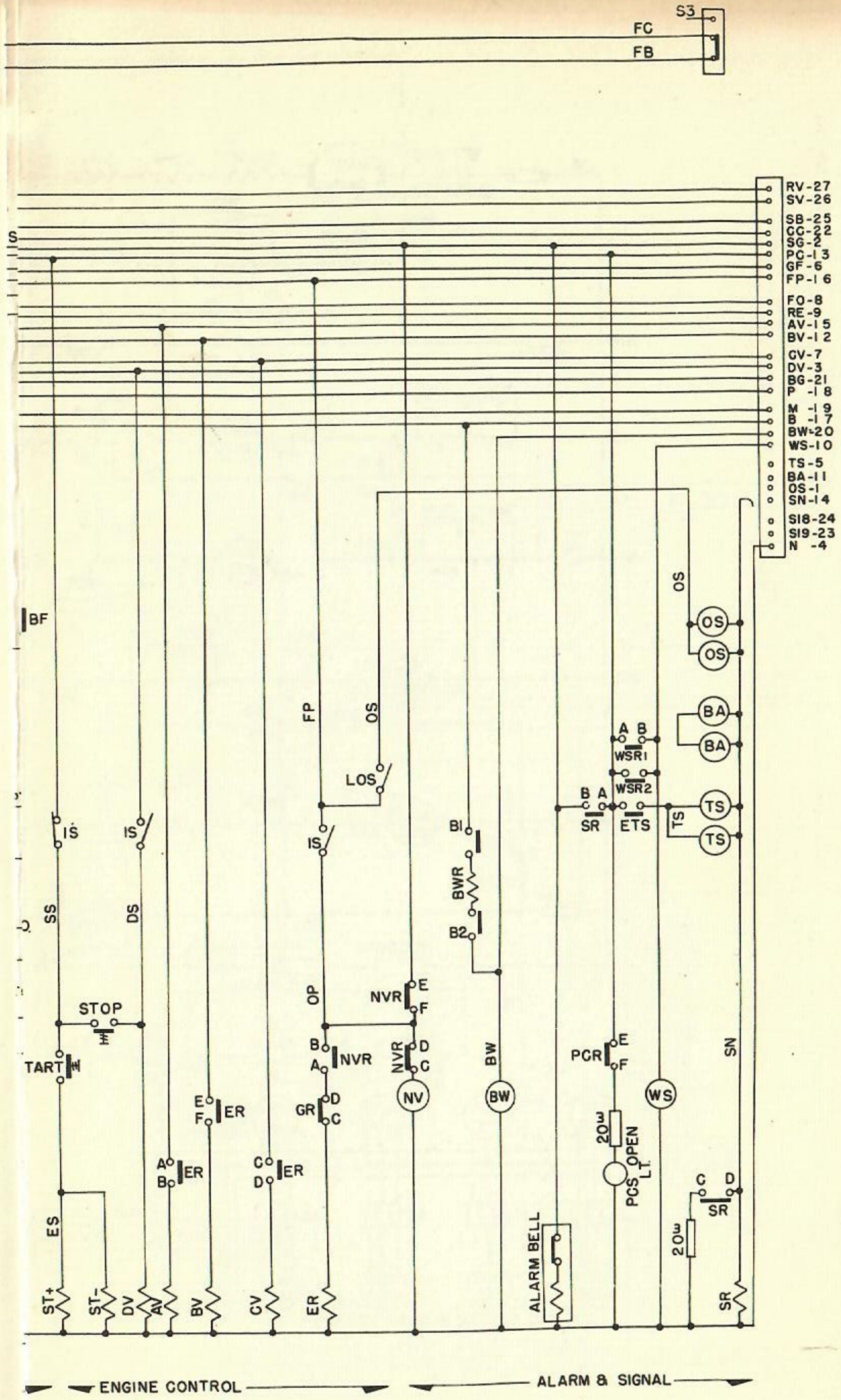
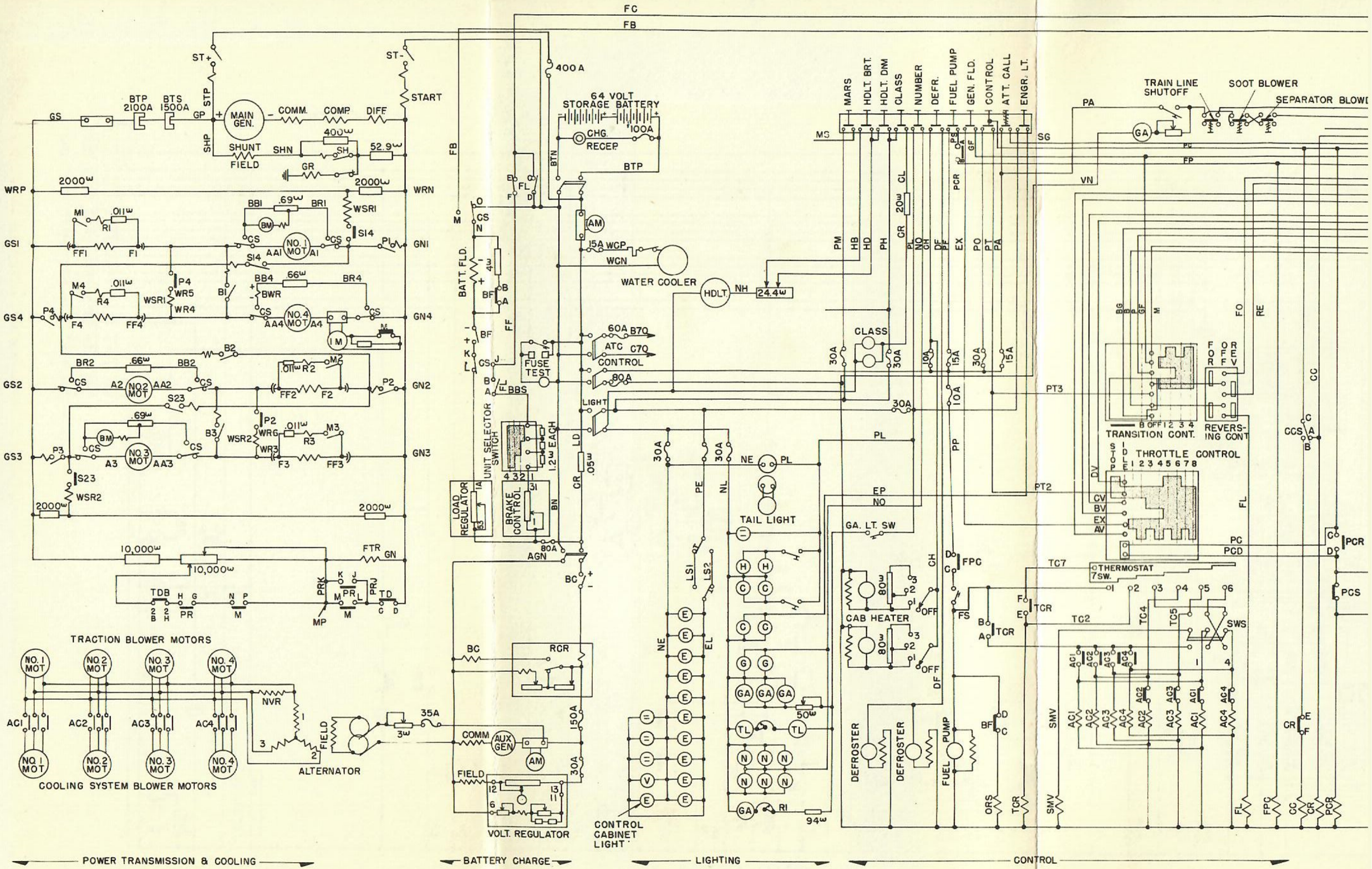
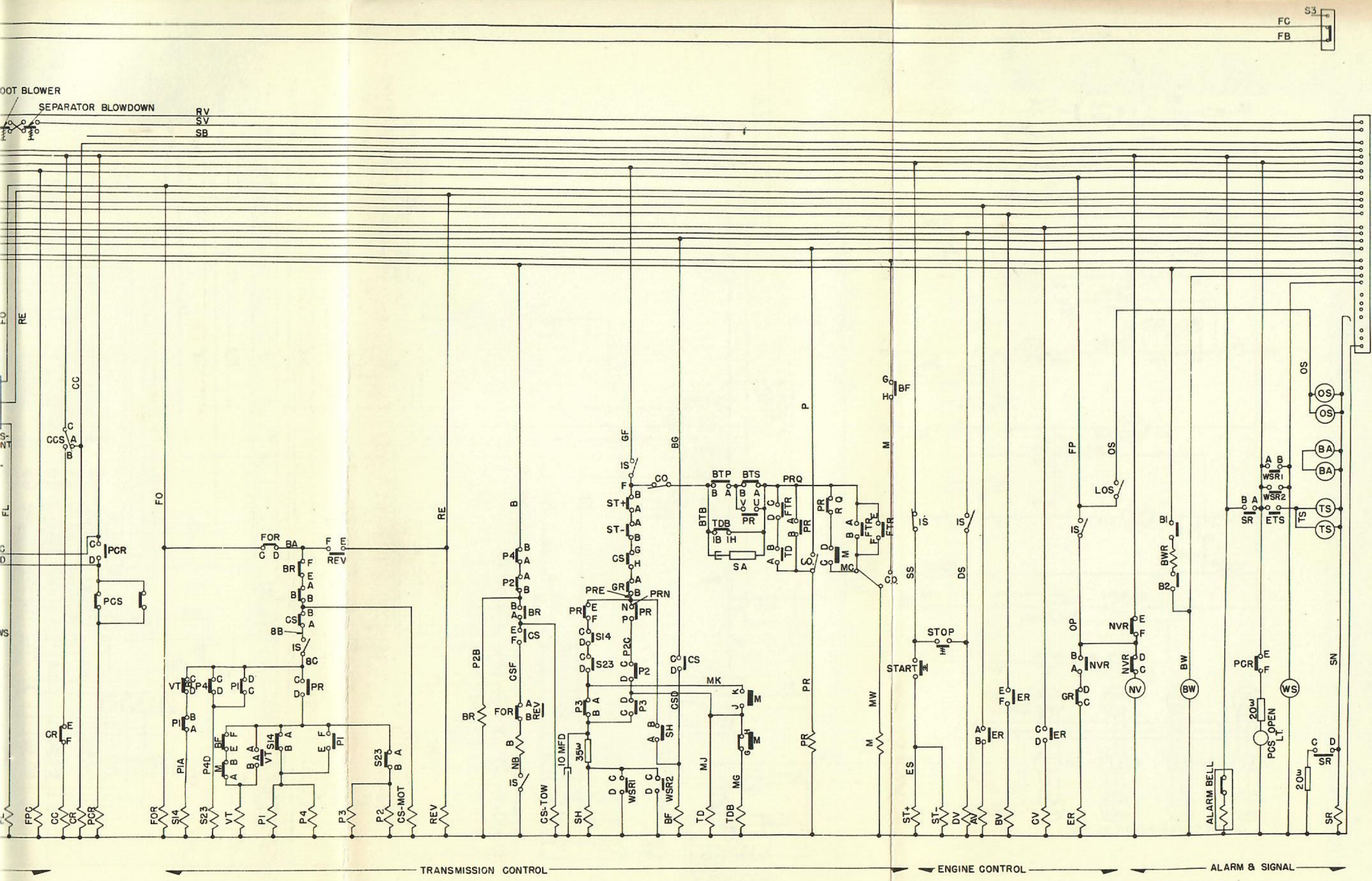

S3
FC
FB
RV-27
SV-26
SB-25
CC-22
SG-2
PC-13
GF-6
FP-16
FO-8
RE-9
AV-15
BV-12
GV-7
DV-3
BG-21
P-18
M-19
B-17
BW-20
WS-10
TS-5
BA-11
OS-1
SN-14
SI8-24
SI9-23
N-4
S
BF
IS
SS
IS
DS
STOP
TART
ES
ST+
ST-
DV
AV
A
B
ER
E
F
ER
BV
C
D
ER
CV
FP
OS
LOS
IS
OP
B
A
NVR
GR
D
C
ER
NVR
E
F
NVR
D
C
NV
BI
BWR
B2
BW
BW
ALARM BELL
B A
SR
PCR
E
F
20ω
OPEN LT.
PCS
A B
WSR1
WSR2
ETS
TS
OS
OS
OS
BA
BA
TS
TS
WS
C D
SR
20ω
SN
SR
ENGINE CONTROL
ALARM & SIGNAL

Chart IX - Part 1 -
Typical Wiring Diagram, -
Part 2 - (On Reverse Side)


FC
FB
ST+
ST-
STP
START
400A
64 VOLT STORAGE BATTERY
100A
CHG. RECEP
BTN
BTP
BTP 2100A
BTS 1500A
GS
GP
MAIN GEN.
COMM.
COMP.
DIFF
SHP
SHUNT FIELD
SHN
SH
400ω
52.9ω
GR
WRP
2000ω
WRN
BB1
.69ω
BR1
BM
NO. 1 MOT
WSR1
S14
M1
.011ω
R1
GS1
FF1
F1
AA1
A1
P1
GN1
M4
R4
P4
WR5
WR4
BB4
66ω
BR4
BWR
NO. 4 MOT
AA4
A4
GS4
F4
FF4
GN4
1M
B2
BR2
.66ω
BB2
NO. 2 MOT
A2
AA2
R2
M2
P2
GS2
FF2
F2
GN2
S23
B3
WSR2
WR6
WR3
R3
M3
NO. 3 MOT
A3
AA3
GS3
P3
F3
FF3
GN3
10,000ω
FTR
GN
TDB
PR
M
PRK
PRJ
TD
MP
TRACTION BLOWER MOTORS
COOLING SYSTEM BLOWER MOTORS
AC1
AC2
AC3
AC4
NVR
ALTERNATOR
FIELD
35A
3ω
BATT. FLD.
BF
FF
CS
FL
BBS
UNIT SELECTOR SWITCH
1.2ω EACH
LOAD REGULATOR
BRAKE CONTROL
AGN
80A
BC
RCR
COMM
AUX GEN
AM
VOLT. REGULATOR
150A
30A
LD
.05ω
CR
15A WCP
WCN
WATER COOLER
FUSE TEST
60A B70
ATC C70
CONTROL
LIGHT
HDLT
NH
24.4ω
NE
PL
TAIL LIGHT
PE
NL
LS1
LS2
EL
CONTROL CABINET LIGHT
GA. LT. SW
50ω
94ω
CLASS
CAB HEATER
80ω
OFF
DEFROSTER
FUEL PUMP
FPC
FS
TCR
ORS
MARS
HDLT. BRT.
HDLT. DM
CLASS
NUMBER
DEFR.
FUEL PUMP
GEN. FLD.
CONTROL
ATT. CALL
ENGR. LT.
MS
SG
TRAIN LINE SHUTOFF
SOOT BLOWER
SEPARATOR BLOWD
GA
PA
PC
FP
VN
PT3
PT2
TRANSITION CONT.
REVERSING CONT
FOR OFF REV
THROTTLE CONTROL
STOP
IDLE
1 2 3 4 5 6 7 8
CV
BV
EX
AV
THERMOSTAT 7SW.
TC7
TC2
TC4
TC5
SWS
SMV
CCS
PCR
PCD
PCS
CR
CC
FL
POWER TRANSMISSION & COOLING
BATTERY CHARGE
LIGHTING
CONTROL

Part 1 — With Automatic Tra
Dynamic Brake A


S3
FC
FB
OOT BLOWER
SEPARATOR BLOWDOWN
RV
SV
SB
RV-27
SV-26
SB-25
CC-22
SG-2
PC-13
GF-6
FP-16
FO-8
RE-9
AV-15
BV-12
CV-7
DV-3
BG-21
P-18
M-19
B-17
BW-20
WS-10
TS-5
BA-11
OS-1
SN-14
S18-24
S19-23
N-4
FO
RE
CC
CCS
PCR
PCS
FL
WS
FO
FOR
BA
REV
BR
CS
8B
IS
8C
PR
VT
P4
P1
P1A
P4D
S14
S23
CR
RE
B
P4
P2
BR
CS
CSF
P2B
FOR
REV
NB
IS
10 MFD
35ω
GF
IS
CO
ST+
ST-
CS
GR
PRE
PRN
PR
S14
S23
P2C
P2
P3
MK
M
SH
WSR1
WSR2
BG
CS
CSD
MJ
MG
BTP
BTS
PRQ
BTB
TDB
SA
FTR
TD
MC
P
PR
BF
CO
M
MW
IS
SS
STOP
START
ES
DS
ER
FP
LOS
OS
OP
NVR
NV
GR
BI
BWR
B2
BW
SR
ETS
WSR1
WSR2
TS
OS
BA
PCR
20ω
PCS OPEN LT.
WS
SR
SN
ALARM BELL
FPC
CC
CR
PCR
FOR
SI4
S23
VT
P1
P4
P3
P2
CS-MOT
REV
CS-TOW
SH
BF
TD
TDB
ST+
ST-
DV
AV
BV
CV
ER
SR
TRANSMISSION CONTROL
ENGINE CONTROL
ALARM & SIGNAL

Automatic Transition Open Circuit
namic Brake And PCR

Chart IX - Part 1 -
Typical Wiring Diagram, -
Part 2 - (On Reverse Side)

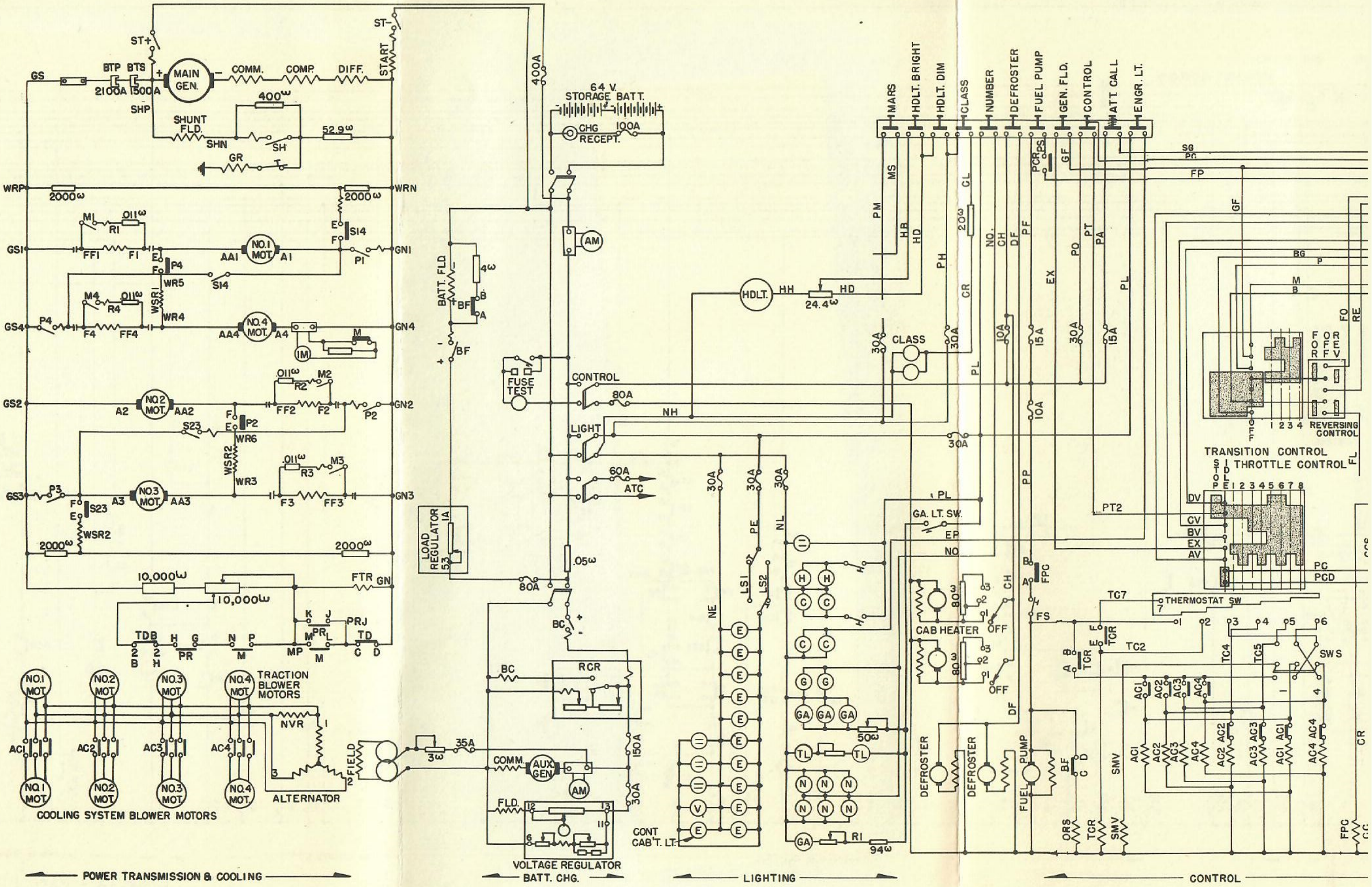
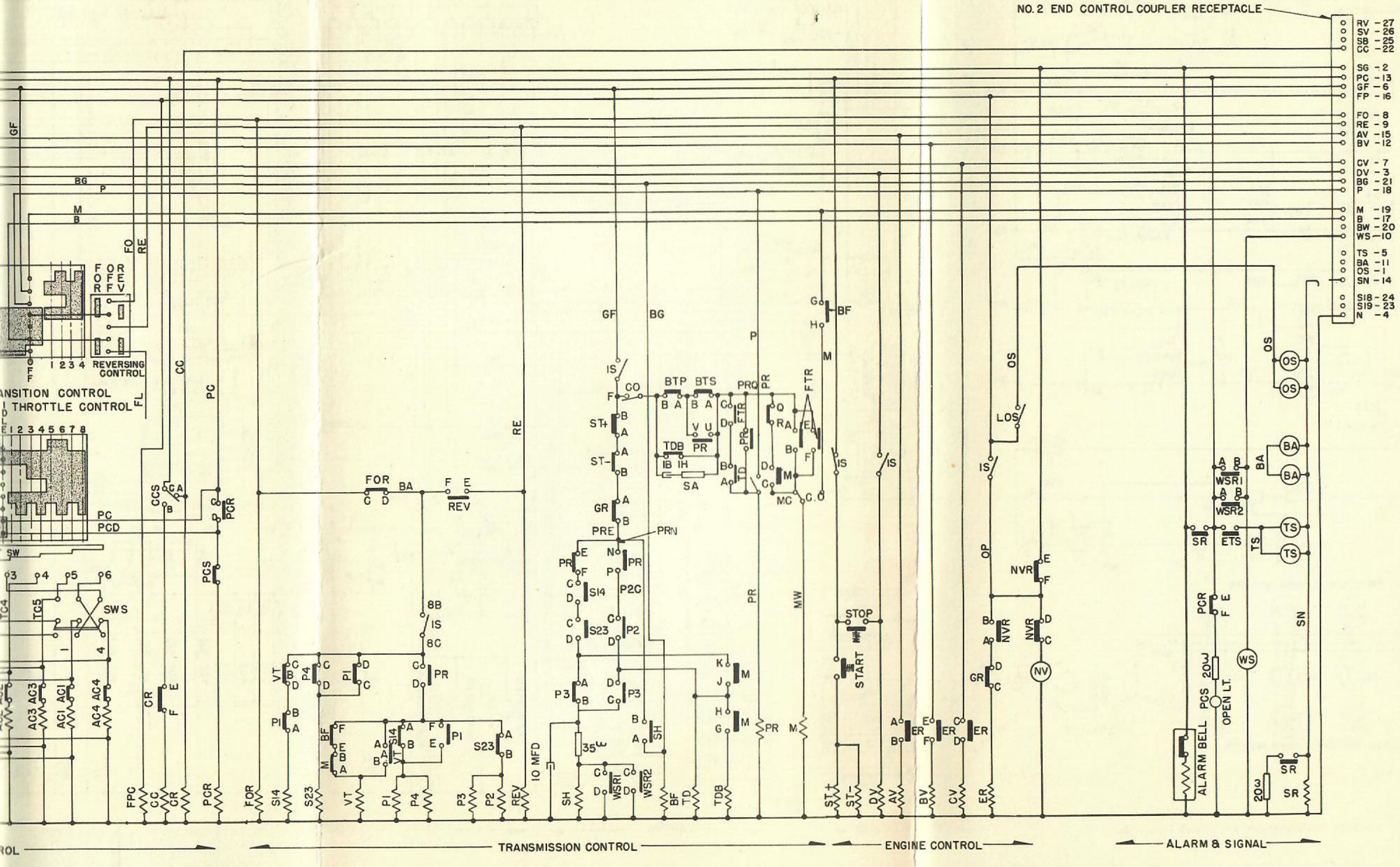
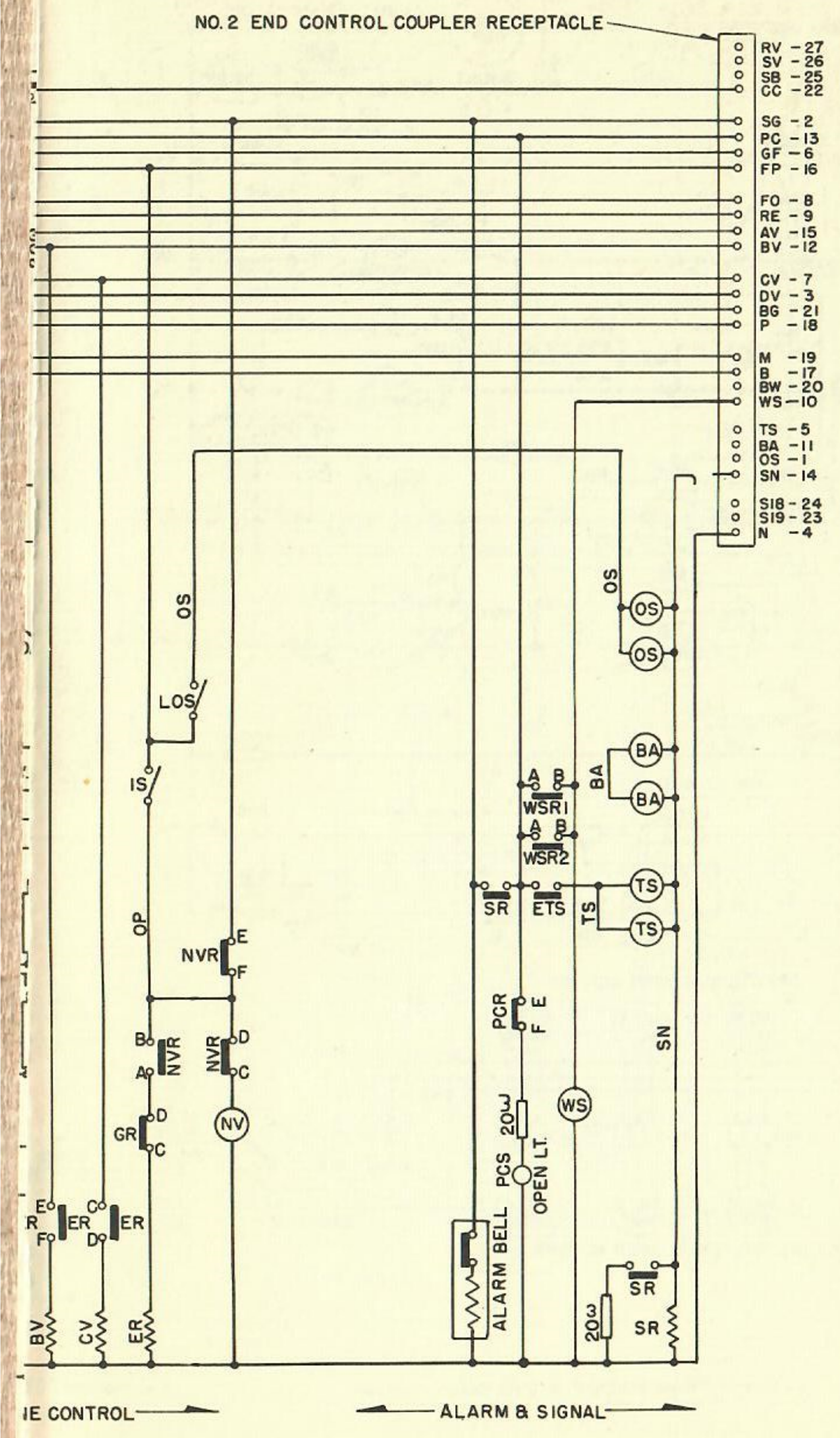

MAIN GEN.
COMM.
COMP.
DIFF.
START
ST+
ST-
BTP
BTS
2100A
1500A
SHP
SHUNT FLD.
SHN
SH
GR
400ω
52.9ω
GS
WRP
WRN
2000ω
GS1
GN1
NO.1 MOT.
GS4
GN4
NO.4 MOT.
GS2
GN2
NO.2 MOT.
GS3
GN3
NO.3 MOT.
S14
S23
WSR1
WSR2
10,000ω
FTR
GN
TDB
PR
PRJ
TD
MP
TRACTION BLOWER MOTORS
NVR
ALTERNATOR
FIELD
COOLING SYSTEM BLOWER MOTORS
AC1
AC2
AC3
AC4
64 V. STORAGE BATT.
CHG RECEPT.
100A
400A
AM
BATT. FLD.
BF
FUSE TEST
CONTROL
80A
LIGHT
60A
ATC
LOAD REGULATOR 53
.05ω
BC
RCR
AUX. GEN.
35A
3ω
150A
30A
FLD.
VOLTAGE REGULATOR
MARS
HDLT. BRIGHT
HDLT. DIM
CLASS
NUMBER
DEFROSTER
FUEL PUMP
GEN. FLD.
CONTROL
ATT. CALL
ENGR. LT.
HDLT.
24.4ω
NH
NE
NL
LS1
LS2
GA. LT. SW.
CAB HEATER
OFF
DEFROSTER
FUEL PUMP
FPC
FS
TCR
TC2
TC7
THERMOSTAT SW
SWS
SMV
ORS
TRANSITION CONTROL
THROTTLE CONTROL
STOP IDLE 1 2 3 4 5 6 7 8
REVERSING CONTROL
FOR OFF REV
CONT CAB'T. LT.
94ω
50ω
POWER TRANSMISSION & COOLING
BATT. CHG.
LIGHTING
CONTROL

Chart IX - Part 2 -
Typical Wiring Diagram

Part 2 — With Automatic Transition Op
Non-Dynamic Brake And PCR


NO. 2 END CONTROL COUPLER RECEPTACLE
RV - 27
SV - 26
SB - 25
CC - 22
SG - 2
PC - 13
GF - 6
FP - 16
FO - 8
RE - 9
AV - 15
BV - 12
CV - 7
DV - 3
BG - 21
P - 18
M - 19
B - 17
BW - 20
WS - 10
TS - 5
BA - 11
OS - 1
SN - 14
SI8 - 24
SI9 - 23
N - 4
REVERSING CONTROL
ANSITION CONTROL
THROTTLE CONTROL
SWS
CCS
PGR
PCS
FOR
BA
REV
SA
STOP
START
NVR
NV
LOS
ER
GR
WSR1
WSR2
SR
ETS
PCR
PCS OPEN LT.
ALARM BELL
WS
OS
BA
TS
10 MFD
ROL
TRANSMISSION CONTROL
ENGINE CONTROL
ALARM & SIGNAL

ic Transition Open Circuit
Brake And PCR


NO. 2 END CONTROL COUPLER RECEPTACLE
RV - 27
SV - 26
SB - 25
CC - 22
SG - 2
PC - 13
GF - 6
FP - 16
FO - 8
RE - 9
AV - 15
BV - 12
CV - 7
DV - 3
BG - 21
P - 18
M - 19
B - 17
BW - 20
WS - 10
TS - 5
BA - 11
OS - 1
SN - 14
S18 - 24
S19 - 23
N - 4
OS
OS
OS
LOS
IS
OP
NVR
E
F
B
A
NVR
NVR
D
C
NV
GR
D
C
E
F
R
ER
C
D
ER
BV
CV
ER
A B
WSR1
A B
WSR2
BA
BA
BA
SR
ETS
TS
TS
TS
PCR
F E
20Ω
PCS
OPEN LT.
WS
SN
ALARM BELL
SR
20Ω
SR
IE CONTROL
ALARM & SIGNAL

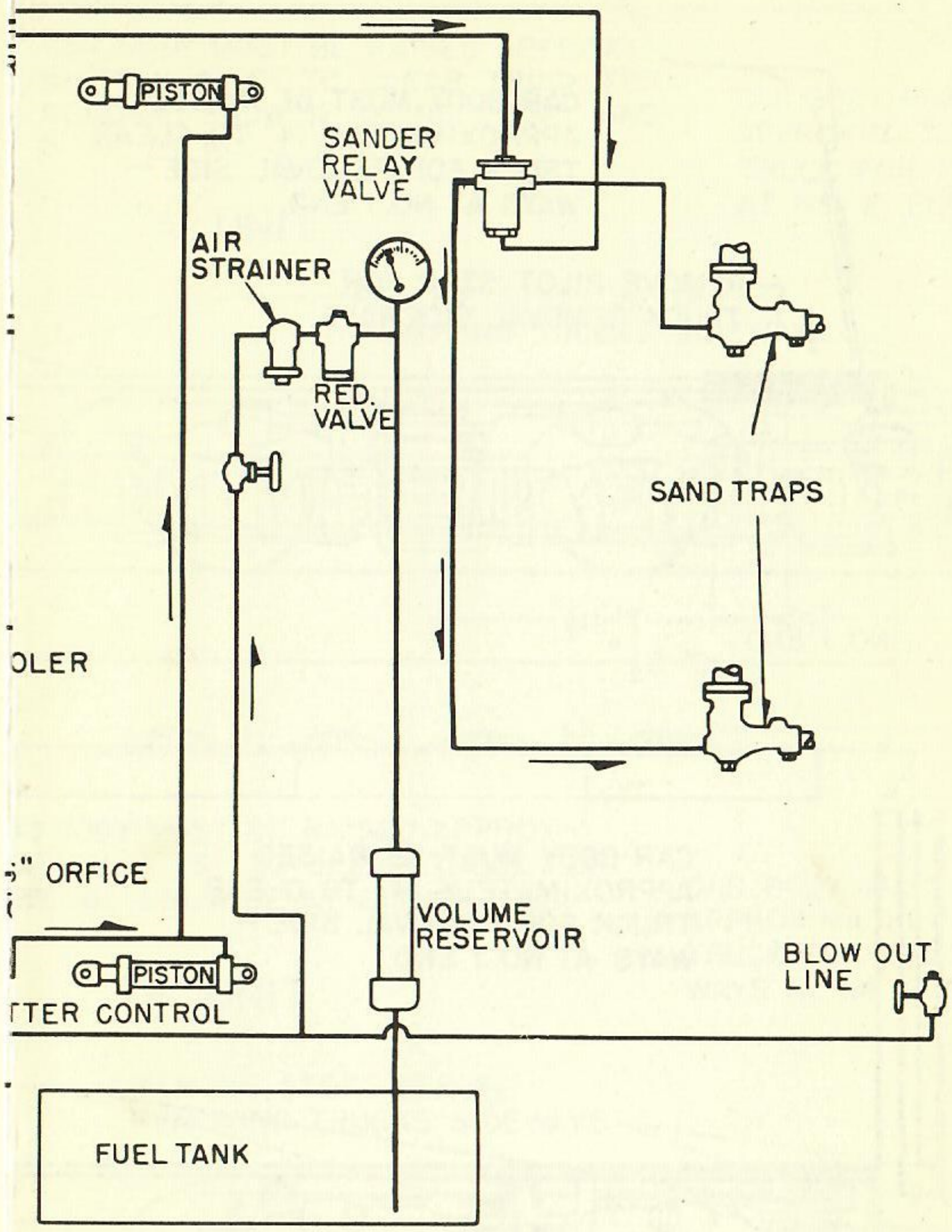
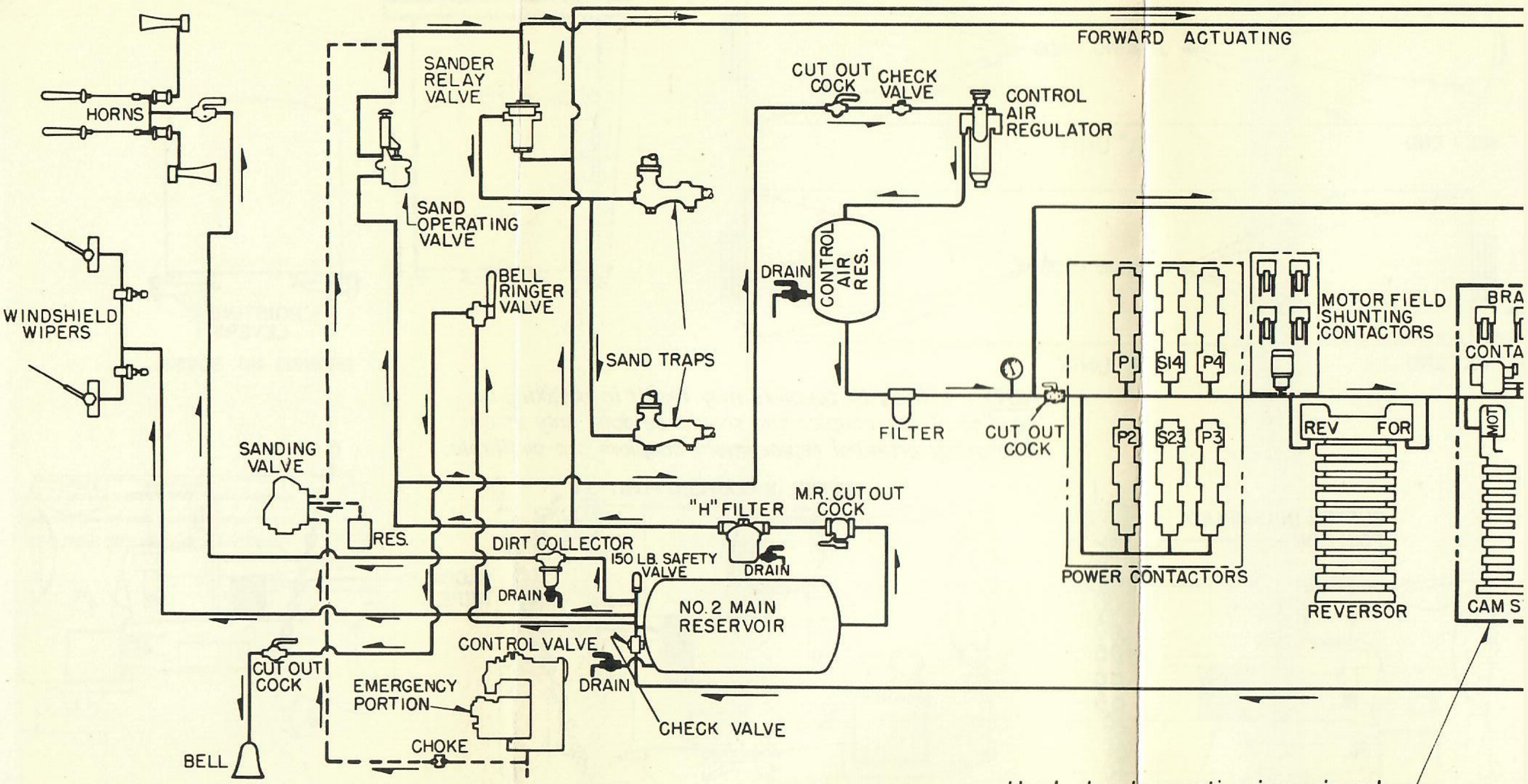

PISTON
SANDER
RELAY
VALVE
AIR
STRAINER
RED.
VALVE
SAND TRAPS
OLER
" ORFICE
PISTON
TTER CONTROL
VOLUME
RESERVOIR
BLOW OUT
LINE
FUEL TANK

Chart X - Schematic Drawing
F3 Freight Locomotive Air Piping
Chart XI - (On Reverse Side),
Truck Removal Diagram


FORWARD ACTUATING
SANDER RELAY VALVE
CUT OUT COCK
CHECK VALVE
CONTROL AIR REGULATOR
HORNS
SAND OPERATING VALVE
WINDSHIELD WIPERS
BELL RINGER VALVE
DRAIN
CONTROL AIR RES.
SAND TRAPS
MOTOR FIELD SHUNTING CONTACTORS
BRA
CONTA
P1
S14
P4
P2
S23
P3
REV
FOR
MOT
FILTER
CUT OUT COCK
SANDING VALVE
"H" FILTER
M.R. CUT OUT COCK
RES.
DIRT COLLECTOR
150 LB. SAFETY VALVE
DRAIN
DRAIN
NO. 2 MAIN RESERVOIR
POWER CONTACTORS
REVERSOR
CAM S
CONTROL VALVE
CUT OUT COCK
EMERGENCY PORTION
DRAIN
CHECK VALVE
CHOKE
BELL

Used when locomotive is equipped with dynamic braking.

Key: ------When locomotive is equipped with automatic emergency sanding

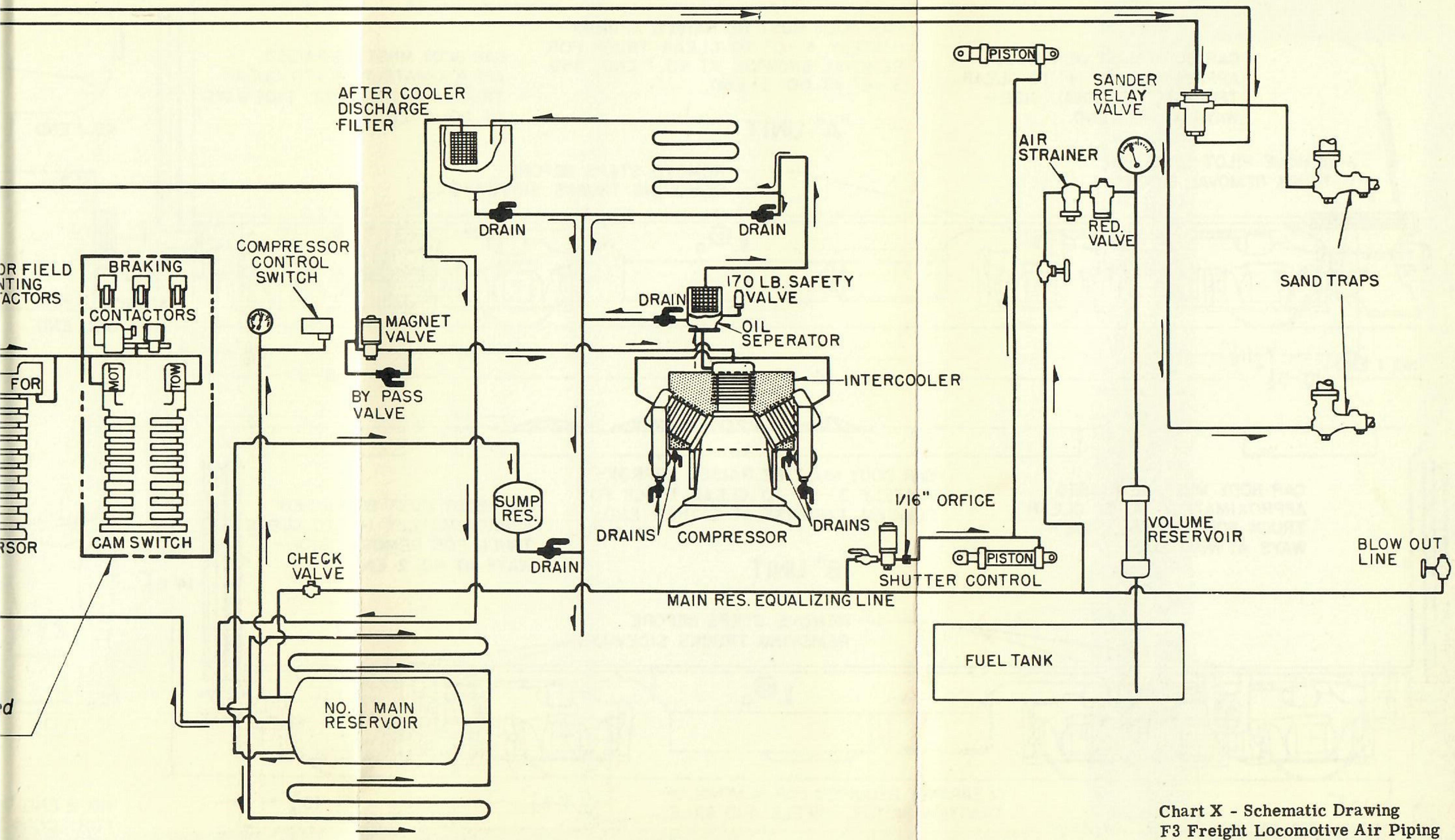
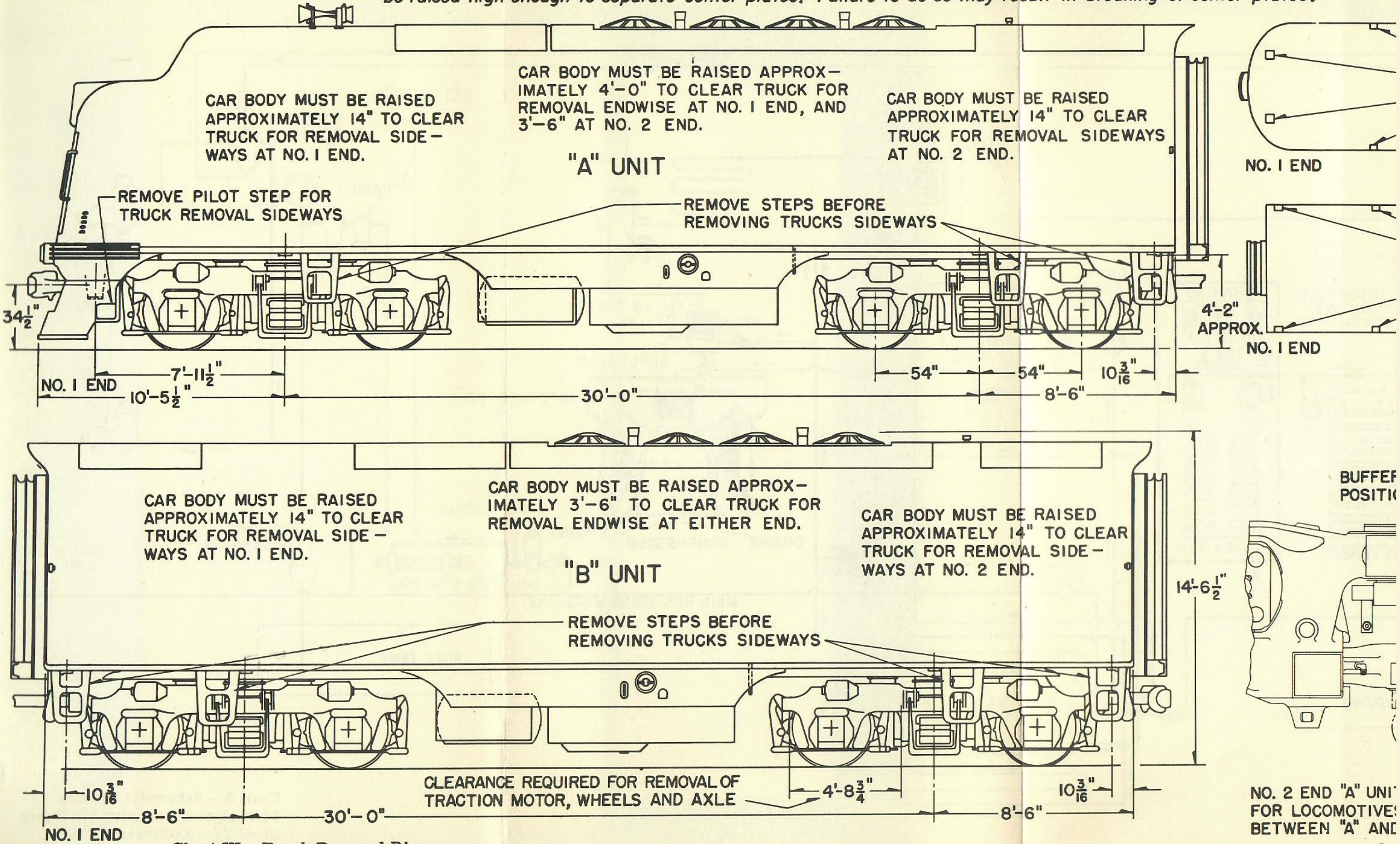

OR FIELD
NTING
ACTORS
FOR
RSOR
ed
BRAKING
CONTACTORS
MOT
TOW
CAM SWITCH
COMPRESSOR
CONTROL
SWITCH
MAGNET
VALVE
BY PASS
VALVE
CHECK
VALVE
SUMP
RES.
DRAIN
NO. 1 MAIN
RESERVOIR
AFTER COOLER
DISCHARGE
FILTER
DRAIN
DRAIN
DRAIN
170 LB. SAFETY
VALVE
OIL
SEPERATOR
INTERCOOLER
DRAINS
COMPRESSOR
DRAINS
1/16" ORFICE
PISTON
PISTON
SHUTTER CONTROL
MAIN RES. EQUALIZING LINE
AIR
STRAINER
RED.
VALVE
SANDER
RELAY
VALVE
SAND TRAPS
VOLUME
RESERVOIR
BLOW OUT
LINE
FUEL TANK

Chart X - Schematic Drawing
F3 Freight Locomotive Air Piping
Chart XI - (On Reverse Side),
Truck Removal Diagram

NOTE: When raising car body for truck removal, the opposite end of car body from truck to be removed must be raised high enough to separate center plates. Failure to do so may result in breaking of center plates.



CAR BODY MUST BE RAISED APPROXIMATELY 14" TO CLEAR TRUCK FOR REMOVAL SIDEWAYS AT NO. 1 END.

CAR BODY MUST BE RAISED APPROXIMATELY 4'-0" TO CLEAR TRUCK FOR REMOVAL ENDWISE AT NO. 1 END, AND 3'-6" AT NO. 2 END.

CAR BODY MUST BE RAISED APPROXIMATELY 14" TO CLEAR TRUCK FOR REMOVAL SIDEWAYS AT NO. 2 END.

REMOVE PILOT STEP FOR TRUCK REMOVAL SIDEWAYS

REMOVE STEPS BEFORE REMOVING TRUCKS SIDEWAYS

CAR BODY MUST BE RAISED APPROXIMATELY 14" TO CLEAR TRUCK FOR REMOVAL SIDEWAYS AT NO. 1 END.

CAR BODY MUST BE RAISED APPROXIMATELY 3'-6" TO CLEAR TRUCK FOR REMOVAL ENDWISE AT EITHER END.

CAR BODY MUST BE RAISED APPROXIMATELY 14" TO CLEAR TRUCK FOR REMOVAL SIDEWAYS AT NO. 2 END.

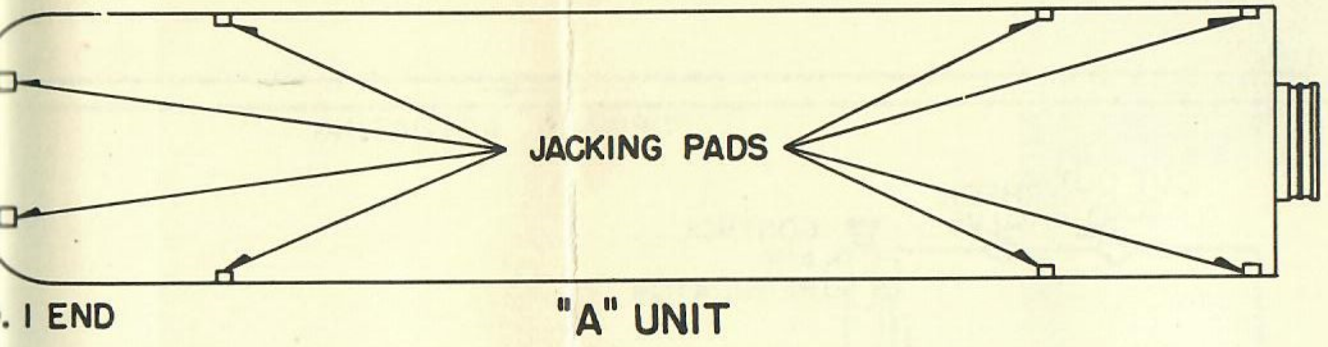
REMOVE STEPS BEFORE REMOVING TRUCKS SIDEWAYS

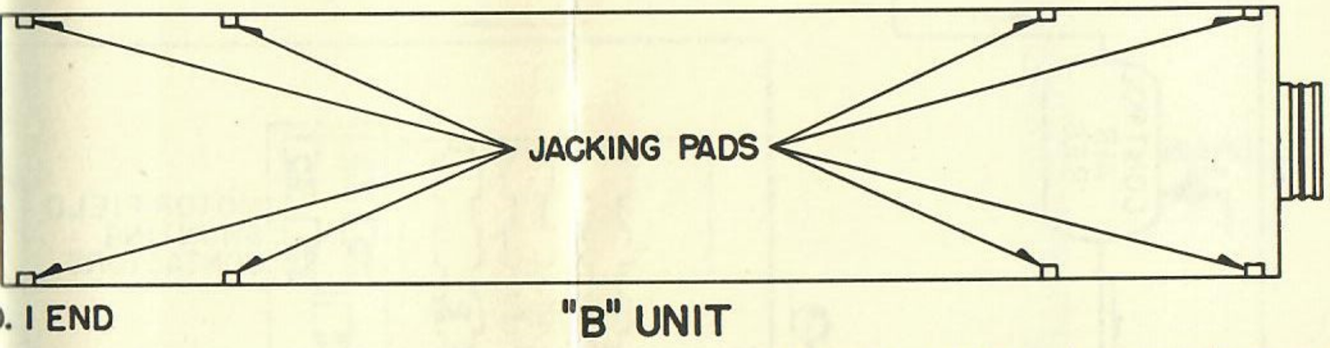
CLEARANCE REQUIRED FOR REMOVAL OF TRACTION MOTOR, WHEELS AND AXLE

"A" UNIT
34½"
NO. 1 END
7'-11½"
10'-5½"
30'-0"
54"
54"
10 3/16"
8'-6"
4'-2" APPROX.
NO. 1 END
NO. 1 END
"B" UNIT
14'-6½"
BUFFEF
POSITI
10 3/16"
8'-6"
30'-0"
NO. 1 END
4'-8¾"
10 3/16"
8'-6"
NO. 2 END "A" UNI
FOR LOCOMOTIVES
BETWEEN "A" AND

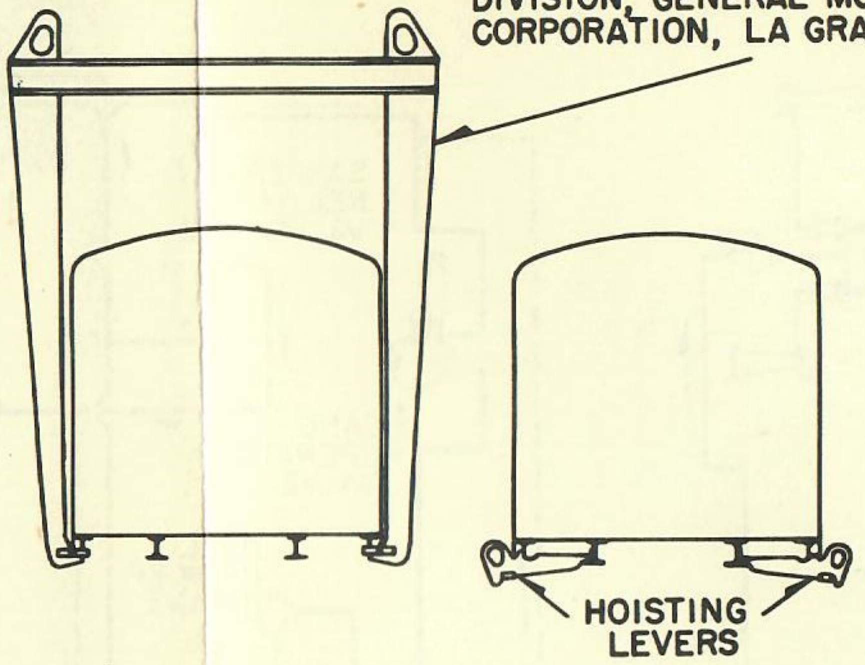
Chart XI - Truck Removal Diagram

ved must
lates.


JACKING PADS
. I END
"A" UNIT

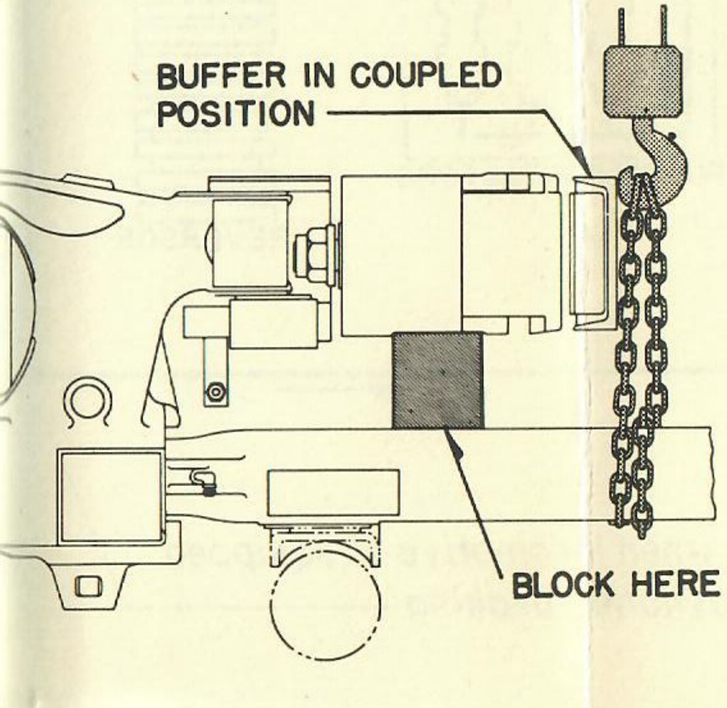

JACKING PADS
. I END
"B" UNIT

OBTAIN CONSTRUCTION DETAILS OF HOOK BY REQUESTING DRAWING NO. 8055964 FROM ELECTRO-MOTIVE DIVISION, GENERAL MOTORS CORPORATION, LA GRANGE, ILL.

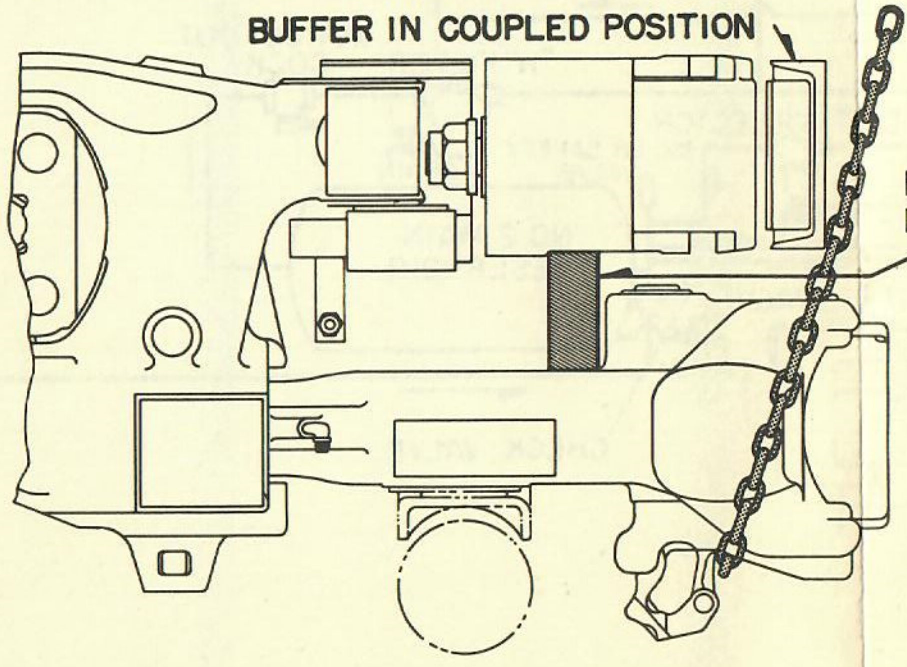

HOISTING LEVERS

DRAWING NO. 8095116

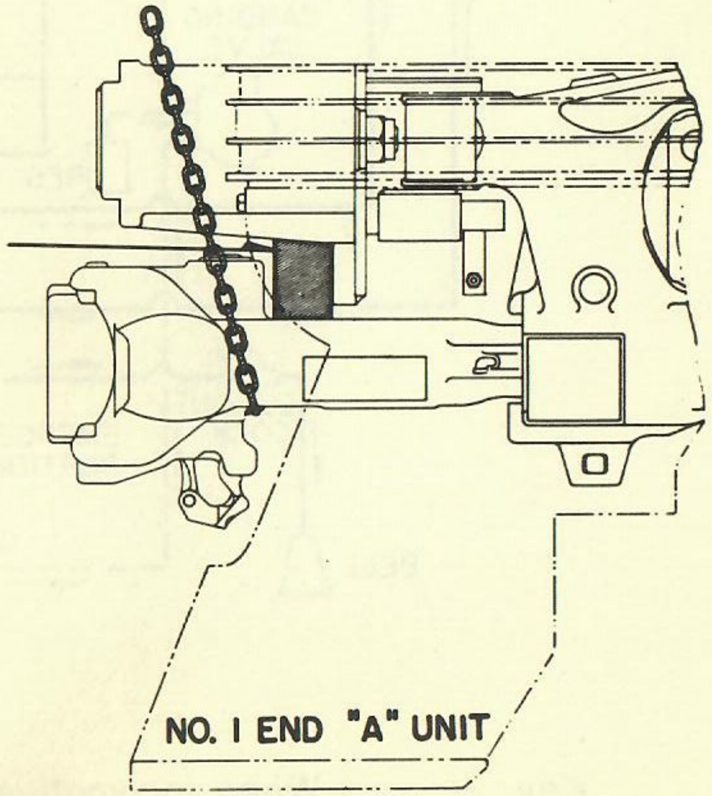
__NOTE__: Lifting by couplers may result in breaking or bending of the coupler and should be done only in an emergency provided replacement couplers are available.


BUFFER IN COUPLED POSITION
BLOCK HERE

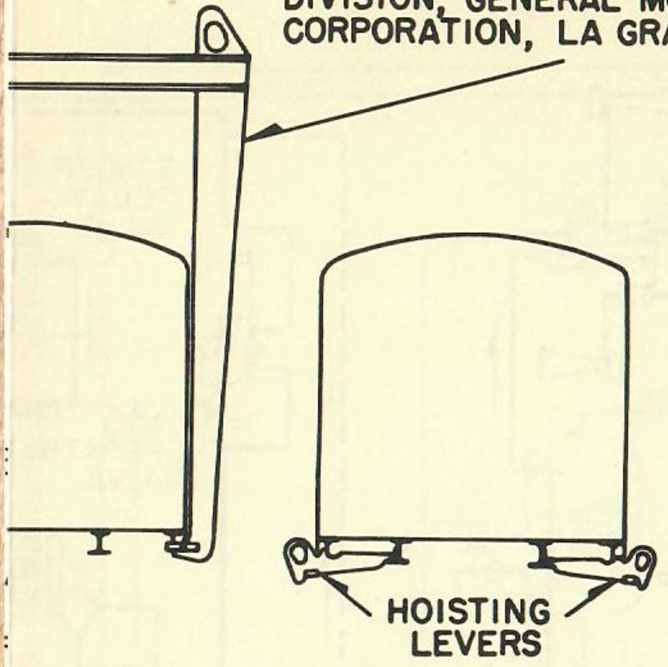
O. 2 END "A" UNIT AND NO. I END "B" UNIT
OR LOCOMOTIVES WITH FIXED COUPLERS
ETWEEN "A" AND "B" UNITS.


BUFFER IN COUPLED POSITION
BLOCK HERE

NO. 2 END "B" UNIT FOR LOCOMOTIVES WITH TYPE "E" AND "H" COUPLERS.

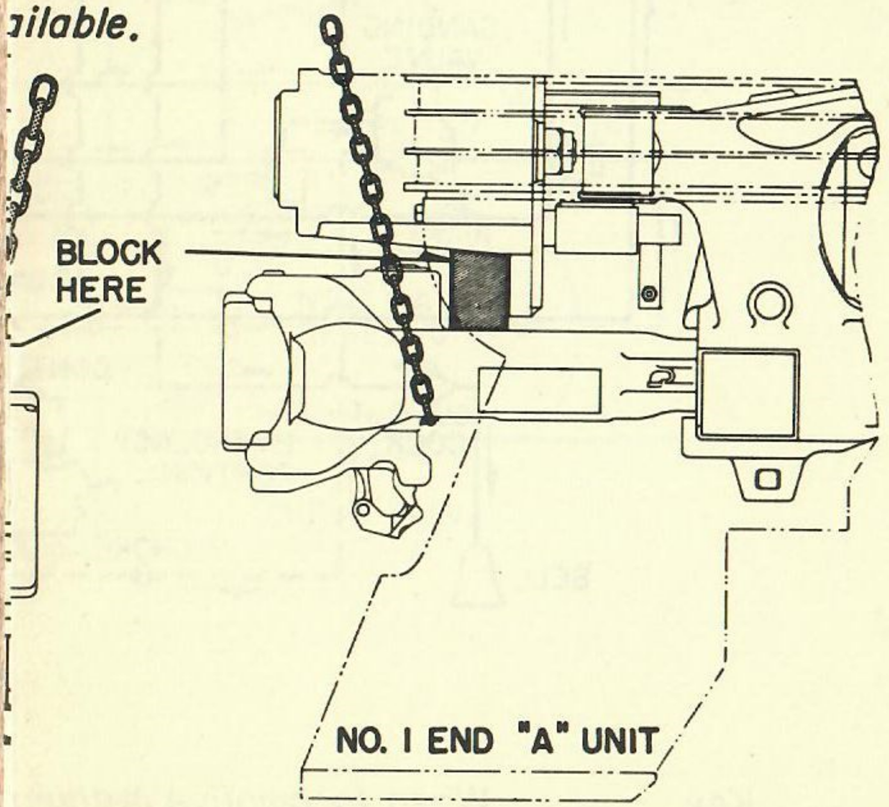

NO. I END "A" UNIT

OBTAIN CONSTRUCTION DETAILS OF HOOK BY REQUESTING DRAWING NO. 8055964 FROM ELECTRO-MOTIVE DIVISION, GENERAL MOTORS CORPORATION, LA GRANGE, ILL.


HOISTING LEVERS

DRAWING NO. 8095116

g or
n an
ailable.


BLOCK HERE
NO. 1 END "A" UNIT

TO MOVE THE LOCOMOTIVE

(Ten Steps Are Necessary)

In the lead unit:

1. Set the PC switch (tell-tale pin down or indicating light not burning) 219
2. Set controls for operation.
   a. Push-in "Control," "Generator Field," and "Fuel Pump" switches on push-button control switch box
   b. Put reverse lever in "Forward" and transition lever in "No. 1" position.
3. 30 ampere and 80 ampere control fuses in distribution panel must be good.
4. Brakes must be released. 218

In each unit:

5. Have engines running.
   If engine must be started:
   a. Low oil pressure trip button on governor must be "in". 139
   b. Overspeed trip lever must be set. 229
   c. Fuel must be flowing through the fuel return sight glass 228
   d. Start engine and "Put on line". 208
6. Isolation switch must be firmly in "Run" position. 226
7. Starting contactors must *not* be stuck closed. 221
8. Ground relay must be set—arrow pointing to yellow dot 224
9. Have control air pressure at 80 pounds. 222
10. Battery field fuse at low voltage panel must be good. . . 230